National Aeronautics and Space Administration

FY 2019

Volume of Integrated Performance

FY 2017 Annual Performance Report
FY 2018 Annual Performance Plan Update
FY 2019 Annual Performance Plan Proposal

www.nasa.gov

Introduction

The *FY 2019 Volume of Integrated Performance*[1] captures the full spectrum of NASA's activities to accomplish National priorities in civil aeronautics research, space exploration, science, technology development and application, and advanced research and development. This report builds upon the *2018 Strategic Plan* framework that establishes long-term goals for all of the Agency's activities. It is also a companion to NASA's *FY 2019 Budget Estimates*,[2] in accordance with the requirements of the Government Performance and Results Act (GPRA) Modernization Act of 2010.

The *FY 2019 Volume of Integrated Performance* consolidates NASA's reports on prior year (FY 2017) performance with an updated performance plan for the current fiscal year (FY 2018), and a proposed performance plan for the requested budget fiscal year (FY 2019). Together, this holistic approach provides a retrospective and prospective view of NASA's performance, consistent with Office and Management and Budget (OMB) guidelines. The document is organized into the following sections.

- **Part 1—Performance Management** at NASA summarizes how the Agency is organized, governed, and managed. It explains NASA as an organization and its approach to strategic planning, performance management and reporting. It describes how the Agency uses data, evidence and evaluations, and reporting to manage performance. Additionally, it describes how NASA prioritizes performance objectives, in response to both Federal and internal Agency mandates. The section also describes how NASA leverages internal reviews to address various management challenges, and includes a discussion of NASA's response to the management challenges identified by NASA's Office of Inspector General in NASA's *FY 2017 Agency Financial Report* and the Government Accountability Office's High Risk List. The section concludes with a brief description of the Agency's enterprise risk management efforts.
- **Part 2—Performance Reporting and Planning** presents NASA's FY 2017 Annual Performance Report, the FY 2018 Performance Plan Update, and the FY 2019 Performance Plan by strategic goal and strategic objective, including descriptions of future plans for each strategic objective. It shows up to six years of historical performance ratings alongside two years of plans for future performance goals and indicators. This presentation provides an opportunity to see performance trends across multiple years within a program, helps the reader visualize linkages and, in turn, see how performance measures roll up to demonstrate the Agency has accomplished incremental progress towards achieving the strategic objectives. Where NASA may not be on target to meet a performance goal or achieve an annual performance indicator, an explanation has been provided describing the situation, and when appropriate, the corrective actions the Agency intends to take.
- **Part 3—Supporting Information** comprises all of the supplemental information: a mapping of strategic objectives from the *2014 Strategic Plan* to the *2018 Strategic Plan*; a list identifying changes made to the FY 2018 Performance Plan Update; and captions and credits for the photographs used in the document.

[1] The *FY 2019 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 2019 Budget Estimates*, which combines the President's budget request and the justification, can be found on NASA's Budget Documents, Strategic Plans and Performance Reports website.

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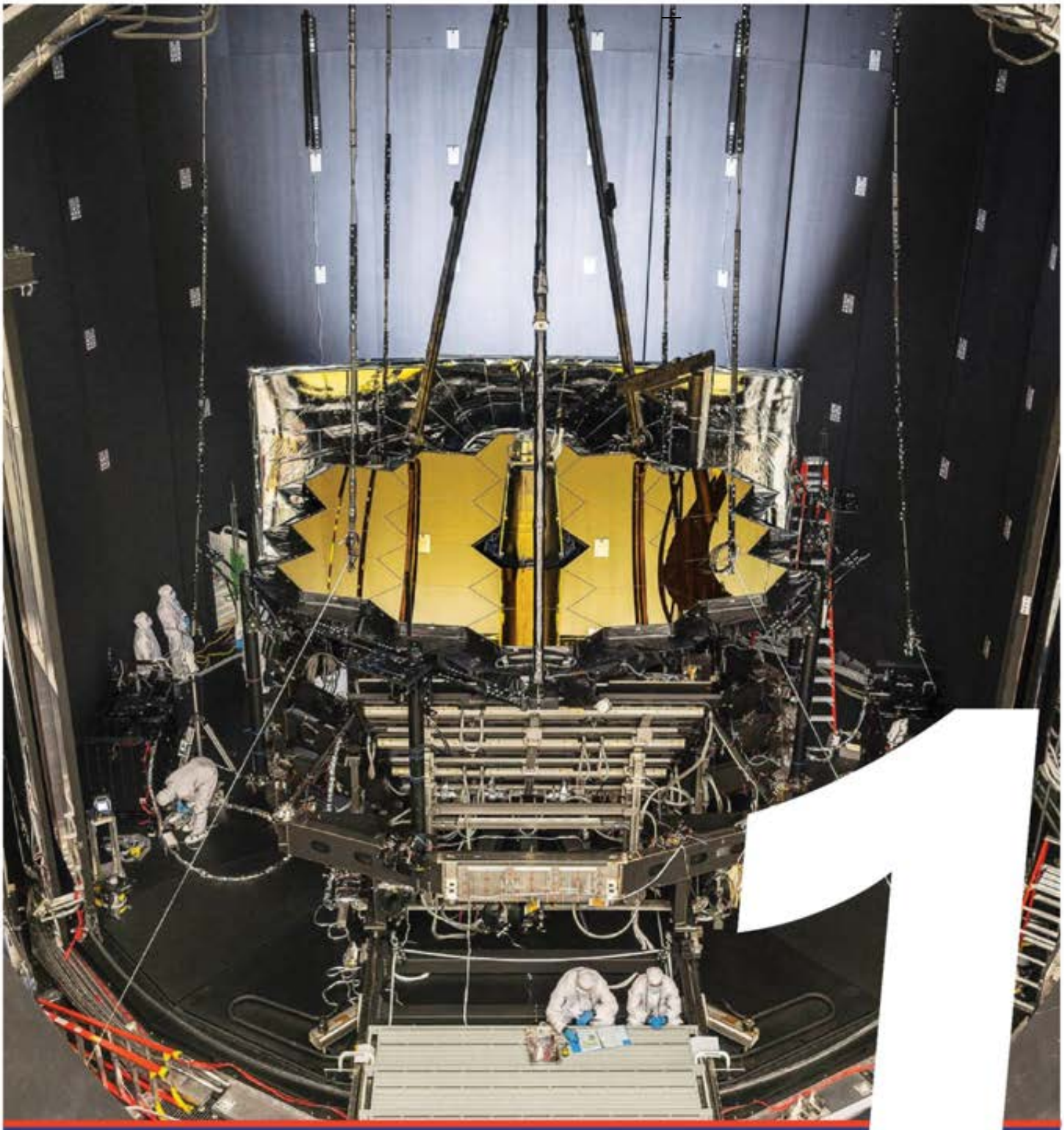


Performance Management at NASA

Part 1 of the *FY 2019 Volume of Integrated Performance* provides an overview of the NASA organization, including the Agency's governance and management structure. The section describes how NASA's organization, management approach, and strategic performance framework support effective mission activities and operations today, and strategically positions the Agency for future missions.

A Performance-Based Organization

NASA is a performance-based organization, committed to managing its resources towards achieving specific, measurable goals derived from a defined mission. The Agency uses performance information to continually improve operations. NASA optimizes the value of its investments by establishing and pursuing ambitious but realizable goals, routinely evaluating performance, using data and evidence in decision making, and holding itself accountable to the public through a transparent assessment framework.

Organizational Structure

NASA's organizational structure comprises a top level leadership structure overseeing a matrixed relationship between mission directorates, mission support offices, and Centers. This structure ensures the Agency can take both a holistic and more narrowly-focused approach to business management, safety oversight, and achievement of mission and operational goals, as described in the *NASA Organization* (NASA Policy Directive 1000.3E). The Administrator and senior officials lead the Agency by providing top-level strategies and direction. Mission directorate and mission support offices at Headquarters manage decisions on programmatic investments and guide the operations of the Centers. NASA's Centers and facilities manage and execute the mission work—engineering, operations, science, and technology development—and supporting activities. The FY 2019 President's budget request announces a planned restructuring of NASA's organization to better support an innovative and sustainable program of exploration.

Headquarters organizations lead Agency budget development, execution, and performance assessment. Provided below are brief descriptions of NASA's mission directorates and select offices. NASA's structure as of early 2018 was the following:

- The Science Mission Directorate (SMD) expands the frontiers of Earth science, heliophysics, planetary science, and astrophysics. Using robotic observatories, explorer craft, ground-based instruments, and a peer-reviewed portfolio of sponsored research, SMD seeks knowledge about our solar system, the farthest reaches of space and time, and our changing Earth.
- The Aeronautics Research Mission Directorate (ARMD) transforms aviation with research to dramatically reduce the environmental impact of flight, and improves aircraft and operations efficiency while maintaining safety in increasingly crowded skies. ARMD also generates innovative aviation concepts, tools, and technologies for development and maturation by the aviation community.
- The Space Technology Mission Directorate (STMD) pursues transformational technologies that have high potential for offsetting future mission risk, reducing cost, and advancing existing capabilities. STMD uses merit-based competition to conduct research and technology development, demonstration, and infusion of these technologies into NASA's missions and American industry. This mission directorate is being refocused as

a new Exploration Research & Technology (ER&T) organization to support exploration as a primary customer.

- The Human Exploration and Operations Mission Directorate (HEOMD) leads human exploration in and beyond low Earth orbit by developing new transportation systems and performing scientific research to enable sustained and affordable human life outside of Earth. HEOMD also manages space communication and navigation services for the Agency and its international partners.
- 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 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 information technology, conducting financial and procurement operations, as well as coordinating international partnerships, legislative affairs, and STEM activities.
- The 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.

NASA is restructuring the Agency to align with the new focus on exploration. As a first major step, the former Space Technology Mission Directorate and advanced technology work in the Advanced Exploration Systems program will be merged into a new Exploration Research & Technology organization. Two further options for the next step in aligning NASA's organizational structure with the Agency's focus on exploration are currently under review:

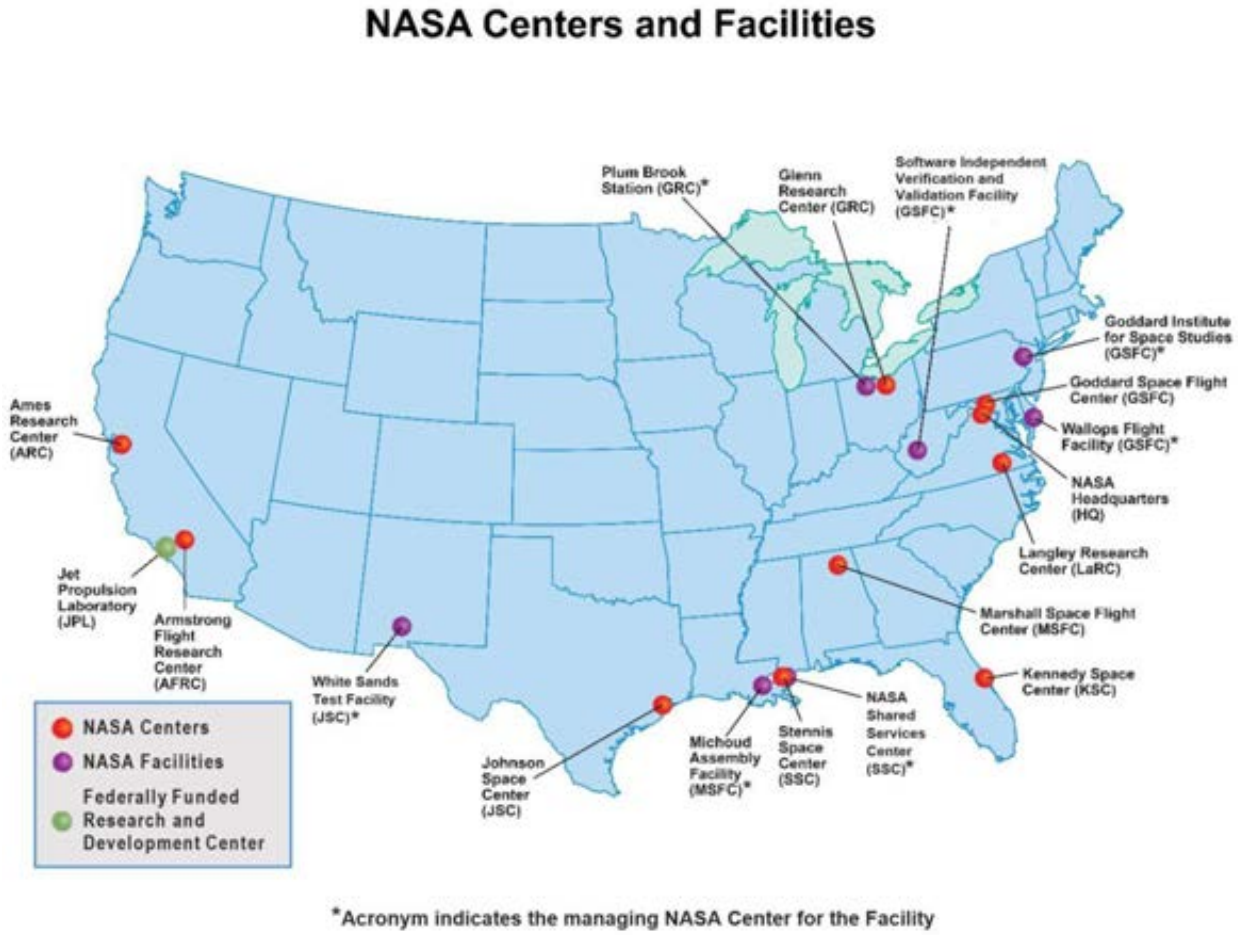
- Option 1: Creating two new exploration-focused mission directorates, eliminating the current HEOMD and STMD structure.
  - Exploration Operations Mission Directorate, which will focus on the International Space Station, commercial low Earth orbit operations, and crosscutting support areas required to support exploration, such as communications, and rocket propulsion.
  - Exploration Systems and Technology Mission Directorate, which will focus on deep space mission elements and technology developments needs for sustainable human exploration.
- Option 2: Creating a single "super" exploration-focused mission directorate, pulling together all the exploration-focused areas in the current HEOMD and STMD.

NASA will choose one of these two options (or potentially a hybrid option) this spring and prepare for implementation with the FY 2019 budget, meaning October 1, 2018.

NASA's Workforce

The NASA workforce of about 17,400[3] civil servants is distributed among its Centers, facilities, and Headquarters. Each location is supported by a contractor workforce providing technical and business operations services.

Figure 1. NASA Centers and Facilities Nationwide



Governance and Strategic Management

NASA is dedicated to results-driven management and is committed to optimizing value to the American public. To achieve mission success, NASA emphasizes continuous collaboration between its Centers, facilities, and Headquarters. The organization manages its operations with checks and balances in the form of increasingly standardized business processes, strategic and performance-based reviews, and governance councils. Additional information on NASA's governance and strategic management can be found in NASA's *Governance and Strategic Management Handbook* (NASA Policy Directive 1000.0B).

[3] NASA Workforce Profile, Workforce Information Cubes for NASA (WICN). Last updated November 8, 2017.

Governance Councils

NASA leaders govern through three Agency-level councils, each with a distinct charter and responsibility. The Executive Council (EC) focuses on major Agency-wide decisions and provides strategic guidance and top-level planning. The Mission Support Council (MSC) is a functional council, focused on mission-enabling decisions. The Program Management Council (PMC) is an integral part of NASA's program and mission decisions, ensuring acceptable performance as programs reach key decision points, the gatekeeping reviews held to determine the readiness of a program or project to progress to the next phase of the lifecycle.

Figure 2. NASA's Governance Councils

Name	Focus
EC	Agency-wide decisions
MSC	Mission-enabling decisions
PMC	Program and mission decisions

In addition to the governing councils, there are several other councils that advise NASA leadership on certain issues. The Senior Management Council (SMC), comprising NASA senior leaders, provides advice and counsel to the EC on Agency issues, and input on the formulation of Agency strategy. The NASA Advisory Council (NAC), a Federal advisory committee established under the Federal Advisory Committee Act (FACA), provides advice and makes recommendations to the NASA Administrator on Agency programs, policies, plans, financial controls, and other matters pertinent to the Agency's responsibilities. For safety performance, the Aerospace Safety Advisory Panel (ASAP) evaluates NASA's safety performance and advises the Agency on ways to improve performance.

Performance Leadership

The GPRA Modernization Act of 2010 requires all agencies to designate a Chief Operating Officer and a Performance Improvement Officer for managing Agency performance. At NASA, the Administrator appoints the Chief Operating Officer and Performance Improvement Officer. Currently, NASA's Associate Administrator serves as the Chief Operating Officer, and the Chief Financial Officer[4] has delegated to the Director of the Strategic Investments Division to serve as the Performance Improvement Officer.

These individuals are responsible for setting goals; assuring timely, actionable performance information is available to decision-makers at all levels of the organization; and conducting frequent data-driven reviews that guide decisions and actions to improve performance outcomes and reduce costs.

Strategic Management

NASA's performance framework (Figure 3) consists of Agency priorities, approaches, and metrics to evaluate and improve progress toward these priorities at varying levels throughout the Agency.

[4] NASA Policy Directive 1000.3E, *NASA Organization*, section 4.1.3.2, April 2015.

Figure 3. NASA's Performance Framework

Strategic Goals

NASA's strategic goals are far-reaching and ambitious, striving to improve knowledge and understanding, and are predicated on a philosophy of continuous growth and improvement. Strategic goals articulate clear statements of what the Agency wants to achieve to advance its mission and address relevant National needs, challenges, and opportunities.

Strategic Objectives

Strategic objectives reflect the outcome or management impact the Agency plans to achieve. The strategic objectives reflect incremental steps for demonstrating progress towards meeting the strategic goals. NASA defined a 10-year timeframe for its strategic objectives, which are aligned with each of the strategic goals, to help drive the formulation of associated performance goals and indicators in NASA's annual performance plans. Additional information on the *2018 Strategic Plan* is presented in Part 2: Performance Planning and Reporting.

Performance Goals and Annual Performance Indicators

To measure the performance of investments towards its strategic goals and objectives, NASA establishes and measures performance against smaller, achievable goals that, taken together, help demonstrate the overall contribution of each investment towards its strategic plan. In its annual performance plan, NASA sets both its multiyear performance goals, which are targets within the four-year span of the strategic plan, and its annual performance indicators, which are designed to show progress achieved during the budget year. The annual performance plan measures and communicates NASA's progress towards achieving its Vision and Mission.

Agency Priority Goals and Cross-Agency Priority Goals

Agency priority goals and cross-agency priority goals are a subset of performance goals that receive additional senior management focus. Agency priority goals reflect the Agency's highest priorities with ambitious targets that can be achieved within two years. Cross-agency priority goals focus on major issues that require active collaboration between multiple Federal agencies

to implement and are intended to accelerate progress on a limited number of presidential priority areas.

Strategic Plan

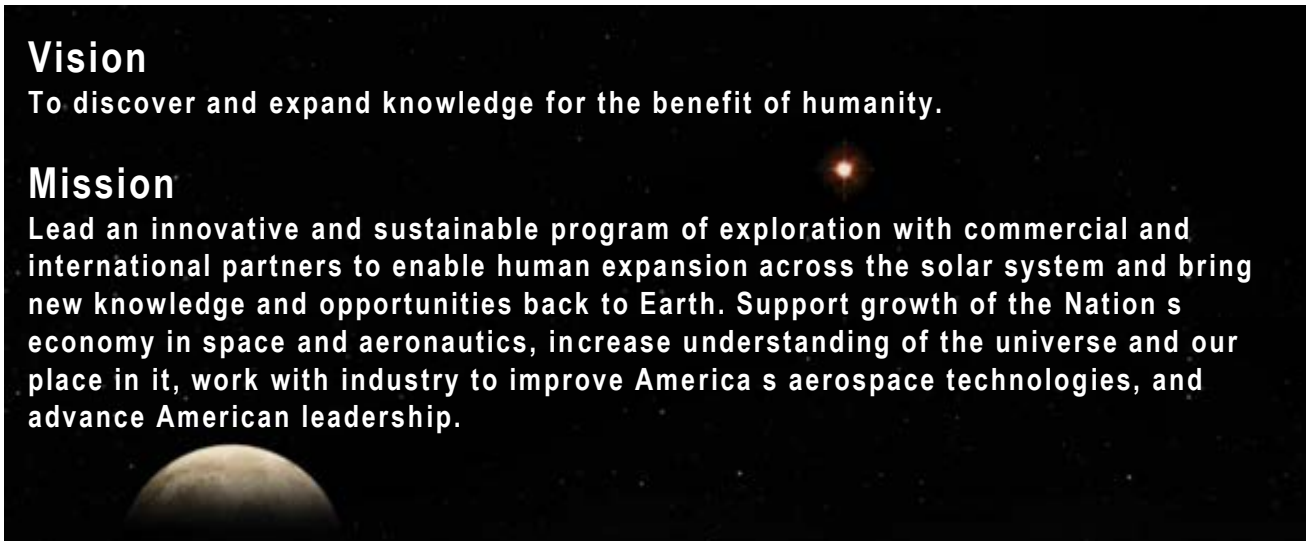
The GPRA Modernization Act of 2010 aligns strategic planning with the beginning of each new term of an Administration, requiring every Federal agency to produce a new strategic plan by the first Monday in February following the year in which the President's term commences. OMB Circular No. A-11 provides detailed strategic planning guidance to implement these statutory requirements.

NASA's *2018 Strategic Plan* outlines the Agency's vision for the future, provides a clear, unified and long-term direction for all of its activities, and sets a new foundation on which the Agency will build and measure the success of its programs and projects. NASA will use this plan to align resources to accomplish its goals in the most effective and efficient way possible.

Vision and Mission

NASA's Vision statement describes the organization's desired future; the Mission statement defines objectives and an approach to reach them. Both statements (see Figure 4) were defined collaboratively through internal and external stakeholder input and published in the *2018 Strategic Plan*.

Figure 4. NASA's Vision and Mission



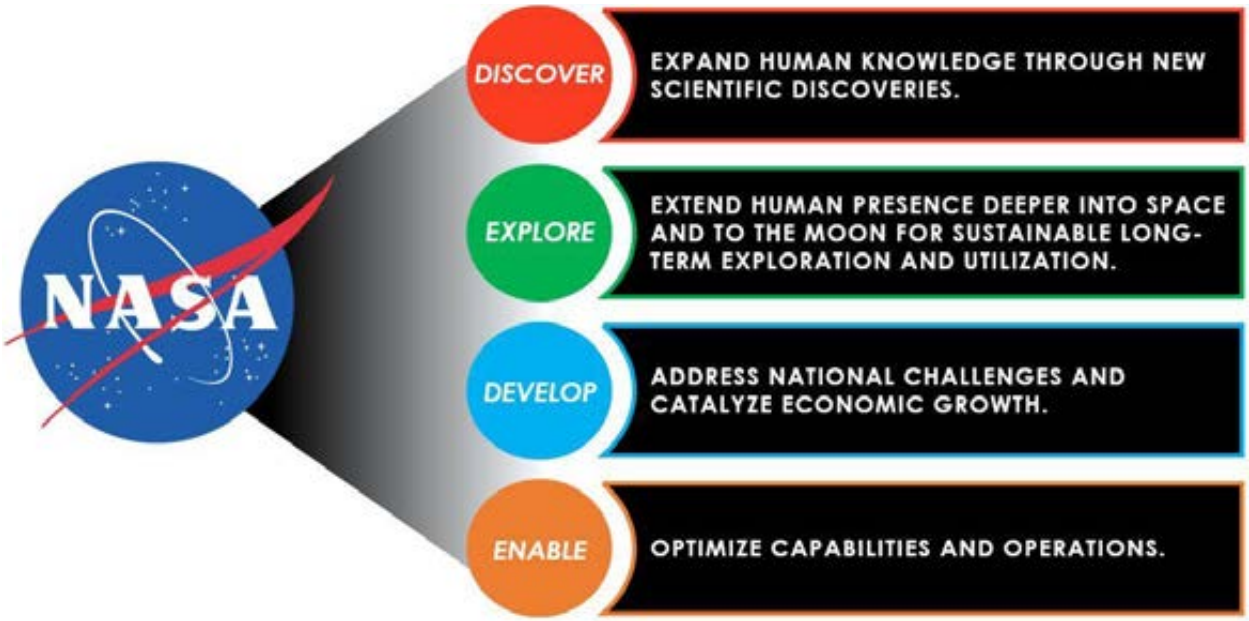
Strategic Themes and Goals

NASA's historic and enduring purpose is aligned to four major themes, characterized by a single word, that are reflected in the Agency's activities.

- ***DISCOVER*** references NASA's enduring purpose of scientific discovery
- ***EXPLORE*** references NASA's push to expand the boundaries of human presence in space
- ***DEVELOP*** references NASA's broad mandate to promote the technologies of tomorrow
- ***ENABLE*** references the capabilities, workforce, and facilities that allow NASA to achieve its Mission

These four themes align to the four strategic goals of the *2018 Strategic Plan,* illustrated in Figure 5.

Figure 5. 2018 Strategic Themes and Goals



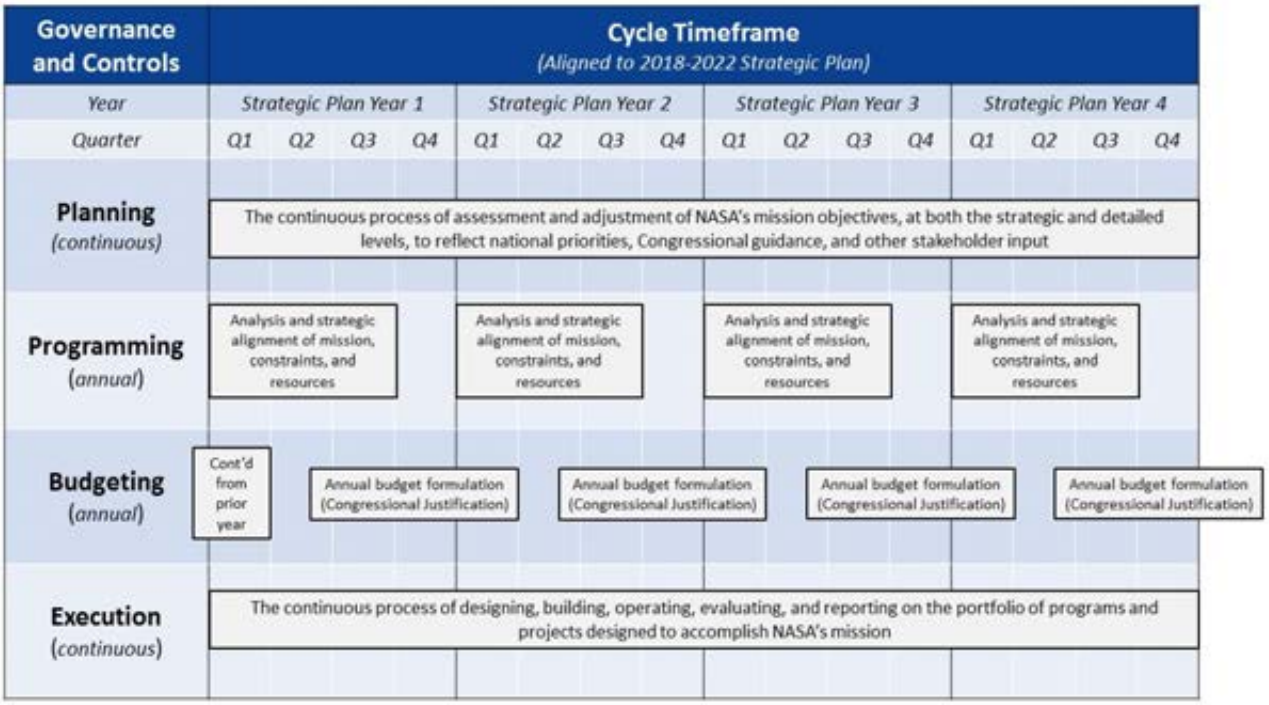
Performance Management

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 system 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.

Performance Planning and Evaluation

NASA plans and evaluates its performance in a continuous cycle, spanning fiscal years and in conjunction with the planning, programming, budgeting, and execution cycle, illustrated in Figure 6.

Figure 6. Planning, Programming, Budgeting, and Execution Cycle



Annual Performance Plan

NASA develops its annual performance plan together with the upcoming fiscal year budget request and releases it to the public on the same date that the Administration releases the annual President's budget request. Accordingly, each year, NASA establishes incremental milestones in alignment with the strategic plan by setting its multiyear performance goals and annual performance indicators in the Agency's annual performance plan.

Annual Performance Plan Update

NASA also evaluates the efficacy of its execution fiscal year measures, as well as planned measures for the upcoming fiscal year. The annual performance plan update reflects any measure revisions, additions, or deletions resulting from these evaluations or due to strategic, budgetary, or programmatic changes that have occurred during budget execution.

The Agency monitors and evaluates performance toward its plans and commitments using ongoing, periodic, and one-time assessments, through which managers identify issues, gauge programmatic and organizational health, and provide appropriate data and evidence to NASA decision-makers. Assessments include:

- Ongoing monthly and quarterly analyses and reviews of Agency activities;
- Annual program and project assessments in support of budget formulation;
- Annual reporting of performance, management issues, and financial position;
- Annual Strategic Reviews of each strategic objective;
- Periodic, in-depth program or special purpose assessments; and
- Recurring or special assessment reports to internal and external organizations.

Performance Assessments, Reviews, and Reporting

During the development of an annual performance plan, the Agency also assesses its performance for the current fiscal year.

Performance Assessments

Once NASA organizations begin executing against the commitments in the annual performance plan, Agency managers and performance analysts monitor and evaluate performance and assess the Agency's progress toward achieving its performance goals and annual performance indicators.

During the third and fourth quarters of each fiscal year, program officials submit to NASA management a self-evaluation, which includes a rating for each performance goal and annual performance indicator and the supporting information that justifies the rating. The results of the performance assessments are presented to NASA's Chief Operating Officer and Performance Improvement Officer, which keeps leadership informed of the Agency's performance progress, allows managers to make course corrections throughout the year to maintain alignment with the strategic goals and objectives, and helps inform budget discussions.

Strategic Reviews

All major Federal agencies are required to perform Strategic Reviews. Congress provides direction for these reviews through the GPRA Modernization Act of 2010, and OMB provides implementation guidance. The Strategic Reviews are an annual assessment of each strategic objective, with an analysis of an Agency's progress toward its strategic direction.

For the Strategic Reviews, NASA identifies risks, challenges, and opportunities, and reviews its progress toward achieving performance goals and annual performance indicators. Based on this self-assessment, the strategic objective leader provides a rating for the strategic objective: demonstrating noteworthy progress; demonstrating satisfactory performance; or being a focus area for improvement.

Performance Reporting

After each performance goal and annual performance indicator has been reviewed, NASA reports the results to the public. NASA publishes its preliminary, summary performance ratings in the annual agency financial report, which is reviewed and approved by the Chief Operating Officer and Performance Improvement Officer prior to publication. NASA then publishes its detailed, final performance assessments in the annual performance report, which includes the ratings (along with any changes made after publication of the agency financial report), rating explanations, and performance improvement plans, where necessary. NASA also includes a summary of Strategic Reviews results with the annual performance report.[5] The annual performance report, along with the annual performance plan, comprise Part 2 of this report.

Agency Priority Goals

In accordance with the GPRA Modernization Act of 2010, NASA identified five agency priority goals for the FY 2018–FY 2019 reporting cycle that will benefit the United States in the areas of human spaceflight, space operations, astrophysics, and planetary science (see Figure 7). The

[5] For FY 2017, OMB postponed external reporting of Strategic Review findings until agencies released their new strategic plans. Part 2 includes an overview of the new strategic objectives. Strategic Reviews reporting will resume in FY 2018.

agency priority goals do not provide a comprehensive picture of every high-profile activity within NASA, but they do represent a number of key projects.

Figure 7. NASA's FY 2018–FY 2019 Agency Priority Goals

Goal Statement	Strategic Objective	Responsible Organization(s)
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.	1.1	SMD: • James Webb Space Telescope Program
Seeking signs of life on Mars: 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.	1.1	SMD: • Mars Rover 2020 Program
Achieve critical milestones in the 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.	2.2	HEOMD: • Exploration Systems Development
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.	2.2	HEOMD, ER&T: • International Space Station Program • Advanced Exploration Systems • Human Research Program

Goal Statement	Strategic Objective	Responsible Organization(s)
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. 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.	4.2	HEOMD: • Commercial Crew Program

More information on NASA's agency priority goals is available at http://www.performance.gov.

Cross-Agency Priority Goals

Per the GPRA Modernization Act of 2010 requirement to address cross-agency priority goals in the Agency strategic plan, the annual performance plan, and the annual performance report, please refer to http://www.performance.gov for the Agency's contributions to those goals and progress, where applicable.

As part of the cross-agency priority goal requirements, agencies complete internal, data-driven reviews of their progress in implementing each of the goals. To meet this requirement, NASA leverages its Baseline Performance Review, which is a monthly forum for the program offices and mission support offices to report on their performance results to NASA leadership. The meetings are data-driven and ensure that performance information is communicated regularly across the Agency. During its highlighted Baseline Performance Review month, the responsible organization for each cross-agency priority goal within NASA reports on its progress towards the goal to the Chief Operating Officer, Performance Improvement Officer, and other senior NASA leadership. This helps to highlight potential areas of concern to Agency leadership and allows for corrective actions, where necessary.

Using Evidence, Evaluation, and Research to Set Strategies and Measure Progress

NASA identifies and mitigates mission challenges, risks, and opportunities by using a variety of evidence, evaluations, studies, and analyses. The Agency uses laws, executive orders, governance, and management best practices to promote a strong culture of results and accountability and manage its programs and activities in the most effective and efficient manner possible. This is achieved, in part, by using a dynamic, data-driven process of conducting rigorous independent evaluations, both internal and external to the Agency. 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 quickly and easily addressed.

Agency managers and analysts use several types of metrics to assess performance, each appropriate to the goals of a specific program or project. For example, assessing cost and schedule progress towards key milestones can be an effective way to determine whether development of a flight project is progressing according to plan. Verification and validation of

data by independent reviewers provides greater confidence in the general accuracy and reliability of the Agency's performance reporting.

Internal Reviews

Baseline Performance Reviews

NASA leadership receives performance information from a variety of sources. For example, NASA conducts an internal assessment and reporting forum, the Baseline Performance Review, which tracks performance against Agency plans. The Baseline Performance Review, led by the Chief Operating Officer, is a bottom-up review of how well the Agency has performed against its strategic goals and other performance metrics, such as cost, schedule, contract, and technical commitments.

Program and Project Reviews

NASA monitors and assesses the engineering processes of designing, building, and operating spacecraft and other major assets. Performance evaluation tools, such as earned value management, are used regularly to assess a project's actual scheduled milestones and costs versus its plan. As detailed 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*, the Agency holds formal internal independent assessments on the progress on its programs and projects through a series of gatekeeping key decision points, which provide credible, objective assessments of how the project is performing. 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 through the lifecycle and authorizes content, cost and schedule for each upcoming phase.

The key decision point reviews 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. key decision points may be scheduled, in accordance with the lifecycle schedule of that project, depending on the formulation, development, or construction plan. NASA conducts additional technical reviews between the key decision points to assess progress and continually monitors overall performance through the Baseline Performance Review. Project performance is independently assessed on a monthly basis and is reported quarterly at the Baseline Performance Review.

Technology Readiness Levels

NASA experts in technology development regularly measure the advancement of each individual technology investment as it progresses through technology readiness levels, a set of progressive criteria and milestones leading from concept to technology maturation and adoption. 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 are performed, often annually, to measure if the Agency's operations and administrative programs are meeting their functional and operational goals. In addition to accomplishing the work, an activity may be assessed for improving operations. These measures may include improvements in output or capacity, increased customer satisfaction, or other

quantifiable estimates of improvement (e.g., reducing operating costs by two percent in two years).

Strategic Reviews

NASA's Strategic Review process is that each strategic objective leader conducts a self-assessment of the impact (looking at the long-term outlook) and implementation (given near-term plans and performance) for their strategic objective. The Agency's Performance Improvement Officer and staff perform a crosscutting assessment to identify common themes and issues. The Performance Improvement Officer's crosscutting assessment also analyzes each strategic objective, validates self-assessment inputs, and performs a relative characterization across all strategic objectives. Based on this assessment, the Performance Improvement Officer recommends an independent rating to NASA's Chief Operating Officer for each strategic objective. Both the self-assessment and the crosscutting assessment use a variety of sources of evidence and inputs.

For the 2017 Strategic Review, the Chief Operating Officer reviewed the summary of the self-assessments and the crosscutting assessment in March 2017 and decided on final ratings for the strategic objectives and next steps for NASA. NASA uses Strategic Review inputs, findings, and results throughout the Agency's budget process and as an input to the annual performance planning process.

External Reviews and Assessments

NASA Science Advisory Committee Strategic Reviews

NASA's Science Mission Directorate manages research programs that may have a broad objective, such as "understanding how the universe works." The Agency conducts annual assessments on these programs, and lessons learned inform the ongoing program decisions. These assessments are done in coordination with the Science Advisory Committees.

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.

Peer and Subject Community Review

NASA relies on evaluations by external communities with expertise in the area under review. 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 or 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.

The National Academies of Sciences, Engineering, and Medicine

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 external evaluations, in combination with performance assessments of ongoing activities, help ensure that NASA's research and development priorities align with the needs of research communities engaged in planetary science, astronomy, heliophysics, and Earth science. The NASA *Space Technology Roadmaps* are a similar planning tool, reflecting the

current and future research and development and technology needs of NASA, the Government, and industry.

Verification and Validation of Performance Information

During the development of the annual performance plan, NASA's mission directorates and mission support offices provide detailed information for each of their performance goals and annual performance indicators, including the frequency of data collection, any data limitations, and known internal or external performance challenges. In addition, program officials provide a brief description of the internal procedures that they will use to determine the end-of-year rating, including the identification of any NASA governance bodies involved in assigning the rating, and list the materials that they will use at the end of the year to verify and validate their performance.

Each year, NASA follows a systematic process to validate its annual performance indicators during the preparation of the annual performance plan. NASA uses a milestone-based approach to its performance reporting, which means the majority of NASA's annual performance indicators are unique to each fiscal year. During the development of the annual performance plan, program officials submit explanations for each of their proposed annual performance indicators, which provide background and explain why a particular indicator is critical to NASA.

Following the end of each fiscal year, NASA selects a subset of its annual performance indicators for verification. The assessment is conducted independently by the Performance Improvement Officer's staff in the Office of the Chief Financial Officer. NASA uses the results of these assessments to improve the quality of its data reporting and inform the development of its annual performance plan during the following year.

Management Challenges

NASA's OIG conducts an annual audit of the Agency's programs and practices, and provides an annual list of the top management and performance challenges. Similarly, the Government Accountability Office (GAO) performs annual audits of NASA's major missions and routinely assesses the Agency's progress on management challenges identified on GAO's High Risk List. GAO's High Risk List, including programs across the Government, is updated every two years, and specifies corrective actions GAO believes necessary to improve critical operations and activities. NASA's acquisition management is a long-standing issue on the GAO High Risk List.

Figure 8 provides a summary of the challenge areas identified by NASA's OIG and GAO in their most recent assessments. For each, NASA identified strategic objectives that will contribute to the mitigation of these challenges to enable Agency leaders to gauge progress and reduce mission risk. Detailed information on specific steps taken in response to OIG and GAO is also provided in this section.

Figure 8. Management Challenges Identified by OIG and GAO

Challenge Area (Source)	External Assessment of Challenge (Excerpted From Report)	Relevant Strategic Objective(s)
Deep Space Exploration (OIG)	"[NASA] must develop more sophisticated rockets, capsules, and related hardware, manage the aging International Space Station (ISS or Station) to maximize its use as a test-bed for research and development of new technologies, and mitigate human health risks of extended space travel – all within the constraints of a static budget profile.[…]NASA will need to begin developing more detailed cost estimates for its […] exploration program after [Exploration Mission-2] to ensure the commitment from Congress and other stakeholders exists to fund an exploration effort of this magnitude over the next decades."	1.2, 2.1, 2.2, 4.2
NASA's Science Portfolio (OIG)	"With a budget that has averaged about $5.3 billion a year over the past 5 years, NASA's Science Mission Directorate focuses on answering questions related to the origins and destiny of the universe; the Sun and its effects on Earth and the rest of the solar system; the Earth's climate; the history of the solar system; and the potential for life elsewhere. In doing so, the Directorate manages about 125 flight projects in various phases of development and operations and funds research drawn from the data provided by these projects. The selection and balance of NASA's science missions is heavily influenced by stakeholders external to the Agency, including the President, Congress, the science community, and, to a lesser extent, other Federal and international agencies. Managing differing priorities from numerous stakeholders and funding changes on a year-to-year basis (which we described as "funding instability" in a September 2012 report) can lead to inefficiencies, resulting in cost increases and schedule delays that can have a cascading effect on NASA's entire science portfolio…."	1.1
Information Technology Governance and Security (OIG)	"Information Technology (IT) plays an integral role in every facet of Agency operations, and hundreds of thousands of individuals—from NASA personnel to members of academia to the public—rely on NASA IT systems every day. In 2017, NASA spent approximately $1.4 billion (7.6 percent) of it [sic] $18.5 billion budget on IT investments. The Agency's portfolio of IT assets includes approximately 500 information systems used to control spacecraft, collect and process scientific data, and enable NASA personnel to collaborate with colleagues around the world.	4.5

Challenge Area (Source)	External Assessment of Challenge (Excerpted From Report)	Relevant Strategic Objective(s)
	For more than 10 years, the OIG has identified securing NASA's IT systems and data as a top management challenge. Over the last 7 years, we have issued 24 audit reports containing over 119 recommendations designed to improve NASA's IT governance and IT security efforts. Although the Agency has made progress in this area, we remain concerned about the state of the Agency's IT governance, its acquisition of IT systems, cybersecurity vulnerabilities, IT security incident detection and handling capabilities, continuous monitoring tools, cloud-computing services, and web application security."	
Aging Infrastructure and Facilities (OIG)	"NASA controls approximately 5,000 buildings and structures with an estimated replacement value of at least $34 billion, making the Agency one of the largest property holders in the Federal Government. However, more than 80 percent of the Agency's facilities are 40 or more years old and are beyond their design life. While NASA strives to keep these facilities operational—and when not operational, in sufficient condition so they do not pose a safety hazard—the Agency has not been able to fully fund required maintenance for its facilities for many years, with NASA estimating its deferred maintenance costs at $2.4 billion in 2016. The Agency faces ongoing operational challenges in this area as it juggles a long history of decentralized governance, intense political interest in its Centers and their real property assets, and the likelihood of flat or reduced budgets."	4.6
Contracting and Grants (OIG)	"Approximately 76 percent of NASA's $18.5 billion FY 2016 budget was spent on contracts to procure goods and services, and the Agency awarded an additional $974 million in grants and cooperative agreements. Accordingly, NASA managers face the ongoing challenge of ensuring the Agency receives fair value for its money and that recipients spend NASA funds appropriately to accomplish agreed-upon goals. The OIG seeks to assist NASA in these efforts by examining Agency-wide procurement and grant-making processes; auditing individual contracts, grants, and cooperative agreements; and investigating potential misuse of Agency contract and grant funds. Additionally, the OIG monitors the impact of contracts and grants awarded to assist NASA in accomplishing its aeronautics, exploration, and science missions as well as to provide support-type functions in areas like information technology."	4.1

Challenge Area (Source)	External Assessment of Challenge (Excerpted From Report)	Relevant Strategic Objective(s)
NASA Acquisition Management (GAO)	"The National Aeronautics and Space Administration (NASA) plans to invest billions of dollars in the coming years to explore space, understand Earth's environment, and conduct aeronautics research. We designated NASA's acquisition management as high risk in 1990 in view of NASA's history of persistent cost growth and schedule delays in the majority of its major projects. Our work has shown that NASA has made progress over the past 5 years in a number of key acquisition management areas, but it faces significant challenges in some of its major projects largely driven by the need to improve the completeness and reliability of its cost and schedule estimating, estimating risks associated with the development of its major systems, and managing to aggressive schedules."	N/A

Response to OIG Management Challenges

Each fiscal year, as required by the Reports Consolidation Act of 2000, 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 (see "NASA's 2017 Top Management and Performance Challenges"). NASA's comments on each management challenge are located in NASA's *FY 2017 Agency Financial Report* (see page 121). The listing of NASA's Top Management and Performance Challenges is a key input to the Agency's leadership when evaluating strategies and making adjustments to plans.

Response to GAO Management Challenges (High Risk)

GAO has identified five criteria that must be met before an agency can remove a focus area from the High Risk List:

1. A demonstrated strong commitment to, and top leadership for, addressing problems;
2. The capacity to address problems;
3. A corrective action plan;
4. A program to monitor corrective measures; and
5. Demonstrated progress in implementing corrective measures.

As part of the *2017 High Risk Report*, *High-Risk Series: Progress on Many High-Risk Areas, While Substantial Efforts Needed on Others* (GAO-17-317), GAO included a scorecard detailing which of these criteria have been met, partially met, or have not been met for each high risk area. NASA has fully met the leadership, corrective action plan, and monitoring criteria, and has partially met the criteria for capacity and demonstrated progress. This rating is unchanged from the *2015 High Risk Report*; however, GAO acknowledged that NASA has continued to strengthen and integrate its acquisition management function.

These changes have yielded more credible cost and schedule baselines and both GAO and OIG observed that NASA's management of its major flight projects has improved. The effectiveness of these tools is particularly evident for the smaller (under $1 billion lifecycle costs)

projects. GAO observed that risks remain for NASA's largest projects, such as the James Webb Space Telescope, the Space Launch System, and Orion. NASA continues to implement measures to improve estimating and management practices for mission costs and schedules.

Enterprise Risk Management

NASA implements enterprise risk management (ERM) in accordance with the update to OMB Circular No. A-123, M-16-17, and OMB Circular No. A-11. ERM provides an enterprise-wide, strategically-aligned portfolio view of organizational risks, challenges, and opportunities. ERM will provide better insight about how to most effectively prioritize and manage risks to mission delivery. 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 organization is implementing ERM to identify, measure, and assess challenges related to mission delivery, to the greatest extent possible. ERM is integrated with the Strategic Review process, providing an analysis of the risks and opportunities NASA faces towards achieving its strategic objectives.

Performance Reporting & Planning

2

How to Read NASA's Performance Data

Introduction

NASA's FY 2017 Performance Report, FY 2018 Performance Plan Update, and FY 2019 Performance Plan, provided in this report, include the short-term, measurable efforts that the Agency is taking to drive and demonstrate progress toward the long-term strategic goals and strategic objectives listed below. This information satisfies Government Performance and Results Act (GPRA) Modernization Act of 2010 requirements for performance reporting of the current year and performance planning of the subsequent year. Part 2 of this document provides an integrated and detailed summary of NASA's FY 2017 performance self-assessment (which comprises most of the annual performance report), the FY 2018 Performance Plan Update, and the FY 2019 Performance Plan. Together, these tools help NASA assess, validate, and demonstrate the annual progress programs and projects make towards its strategic goals for human and robotic space exploration, aeronautics, sciences, technology development, and more. The following sections explain how NASA's performance information is organized and presented in Part 2.

How are the performance data organized?

Below, Figure 9 shows the framework in the *2018 Strategic Plan*. The following performance reporting and planning information is organized according to this strategic framework.

Figure 9. NASA 2018 Strategic Themes, Goals, and Objectives

Thrust	Strategic Goal	Strategic Objective
DISCOVER	Expand Human Knowledge through New Scientific Discoveries.	1.1: Understand the Sun, Earth, Solar System, and Universe. 1.2: Understand Responses 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.	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 Human Exploration in Deep Space, Including to the Surface of the Moon.
DEVELOP	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 Engage the Public in Aeronautics, Space, and Science.
ENABLE	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.

What are the different levels of the performance framework structure?

The data follow the performance framework structure illustrated in Figure 3 of Part 1 of this document. NASA's strategic goals are separated by a full page divider with a color-coded bookmark bar in the top-left corner.

Strategic objectives have the color-coded bookmarks on the banners of their corresponding strategic goal. For example, the red from the Strategic Goal 1 "*DISCOVER*" divider appears on all strategic objective banners under Strategic Goal 1 (see Figure 10).

Figure 10. Strategic Objective Banner with Red Bar Corresponds to Strategic Goal 1 Divider

Performance goals (PGs) describe the multiyear performance of a program or project. They typically last four years and cover the lifecycle of a strategic plan. An example of a PG may be to send a satellite into orbit by a certain date. PGs are the "parents" to the annual performance indicators (APIs).

Annual performance indicators only last a single year. An example of an API may be to complete a phase of satellite development, which leads to a launch date. APIs are the "children" to the "parent" PGs. Every API is associated with a single higher-level PG. Every PG must have at least one API, but may have multiple APIs.

To make each level easier to identify, performance information in this volume is presented as illustrated in Figure 11.

Figure 11. NASA Hierarchy of Performance Data

Strategic Goal #

Strategic Objective #.#

Performance Goal #.#.#

Annual Performance Indicator #.#.#: NAME

What are the ratings and what do they mean?

There are four possible ratings for each PG and API. The first three ratings follow a "stoplight"-style rating system, illustrated in Figure 12 below. The mission directorates define their own parameters for the success criteria during the development of their performance measures, so the success criteria are unique to each PG or API. The generic success criteria in the figure below are illustrative of the types of individualized criteria assigned to each performance measure and broadly apply to the performance measures.

Figure 12. Generic Performance Goal and Annual Performance Indicator Success Criteria

Green	Yellow	Red
On Track or Complete	***Slightly Below Target and/or Behind Schedule***	***Significantly Below Target and/or Behind Schedule***
NASA completed or expects to	NASA completed or expects to complete this performance measure, but is slightly below the target and/or moderately 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.

The fourth rating type is a white rating, which is reserved for when a performance measure cannot be assessed against its success criteria and NASA senior management cancel or postpone the measure. This means NASA is no longer pursuing activities related to this performance measure or the program did not have activities during that fiscal year. Program officials do not develop measure-specific success criteria for white ratings, and only NASA's Chief Operating Officer can assign white ratings.

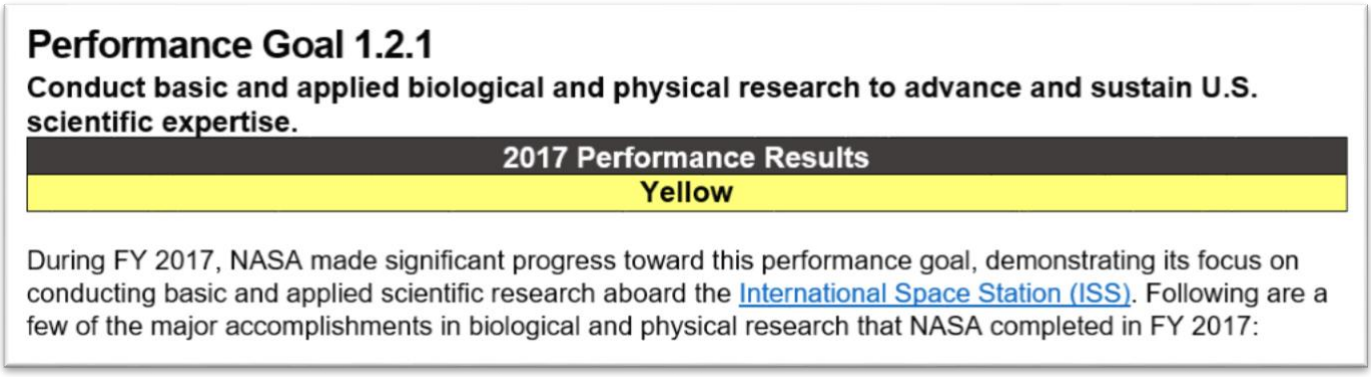
How can a PG be rated one color but its related API(s) be rated a different color?

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 the APIs or they may be based on additional information. For example, the PG may be rated green but the supporting API is rated yellow. This scenario may indicate that that a project's multiyear progress was not hindered by performance challenges in a single fiscal year.

How do I find the PG rating?

Each performance goal has a number (#.#.#) that indicates its level in the performance framework and location within the list of strategic objectives, a measure definition, the fiscal year rating, a rating explanation, and if the rating is not green, a performance improvement plan. See the corresponding elements in Figure 13 below:

Figure 13. Example of a Performance Goal Rating



How do I read the historical performance of a PG?

For each PG, NASA provides a table of information summarizing the ratings for the last completed fiscal year (FY 2017 for this edition) performance rating and five years of historical performance ratings. The table will note if the PG does not have ratings (e.g., the PG did not exist) in previous years by saying "No PG" as shown

in Figure 14. Note that the PG's number may have changed over time due to changes in the framework, and this numbering change information is not available in this report.

Figure 14. Example of Performance Goal Historical Performance

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	Green	Yellow	Green

Why are some PGs and APIs not trending?

When a measure is discontinued, it does not trend into the next year and will state "No PG" or "No API." When a PG or API is created, the history of that measure will similarly display "No PG this fiscal year" or "No API this fiscal year," respectively.

How do I read the Planned Future Performance?

Performance goals that continue beyond FY 2017 provide the performance goal language for the next two fiscal years. The table will state "No PG this fiscal year" if a PG is not scheduled for renewal.

Figure 15. Example of a Future Performance Table

Planned Future Performance (PG 1.1.4)

Year	Description
2018	1.1.4: By December 2019, launch one mission in support of Heliophysics.
2019	1.1.4: By December 2019, launch one mission in support of Heliophysics.

What are the Data Quality Elements?

The data quality elements describe how NASA ensures the accuracy and reliability of the data it uses to measure progress toward each of its performance goals. These include the sources for 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.

How do I find an API's rating?

For each annual performance indicator, tables indicate the FY 2017 rating, the FY 2017 measure definition, and planned APIs, if any, for FY 2018 and FY 2019 as shown in Figure 16.

Figure 16. Example of an Annual Performance Indicator Rating

Annual Performance Indicator 1.1.4: HE-17-6

Year	Description
Rating	Green
2017	HE-17-6: Complete the Ionospheric Connection Explorer (ICON) Pre-Ship Review (PSR).
2018	HE-18-8: Launch the Ionospheric Connection Explorer (ICON).
2019	No API this fiscal year.

What is a Legacy Performance Goal?

Performance goals that do not continue beyond FY 2017 are considered legacy. These measures are presented under the relevant strategic objective from the 2018 strategic plan framework, but with their original numbering from the 2014 strategic plan framework. A legacy performance goal includes an explanation of performance, historical performance, data quality elements, and any child APIs that do not continue beyond FY 2017.

Summary of Performance

Figure 17 provides a summary of NASA's assessment of progress for the Agency as a whole. Figure 18 illustrates NASA's assessment of progress by strategic goal. Additional information regarding the strategic objectives, performance goals, and annual performance indicators, including explanations for those rated yellow or red, is provided in this section and organized by strategic goal and strategic objective.

Figure 17. Quantitative Summary of FY 2017 PG and API Ratings[6]

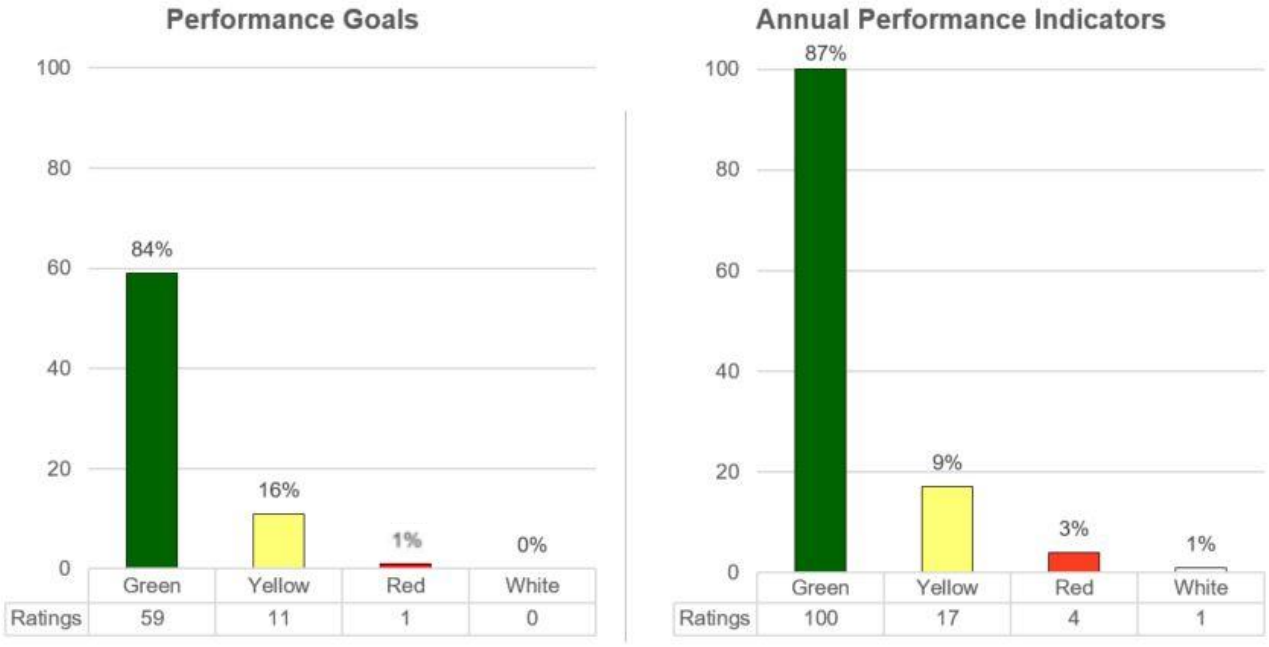
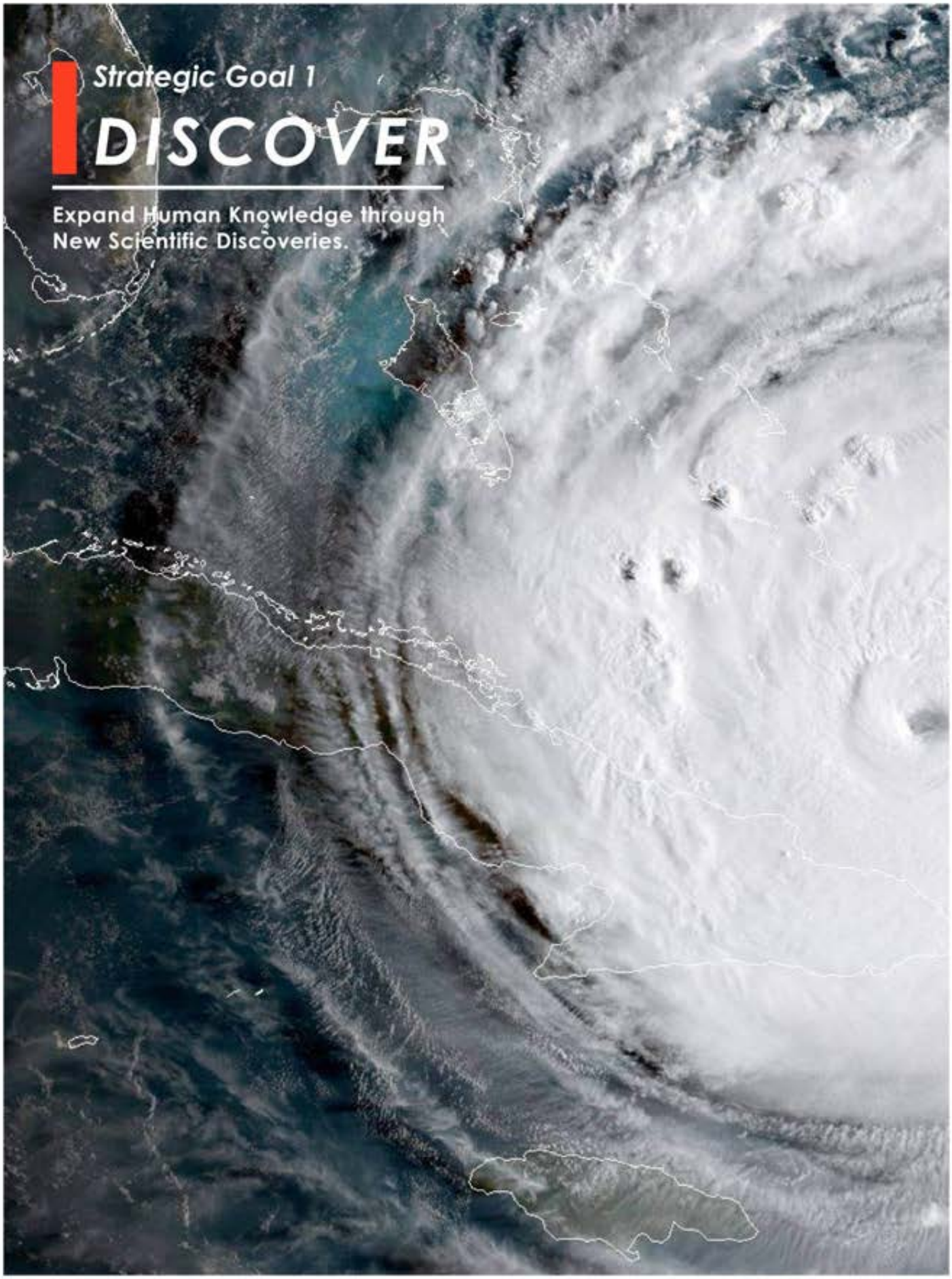


Figure 18. Percentage Summary of FY 2017 PG and API Ratings by Strategic Goal

[6] The sum of percentages may not equal exactly one hundred percent due to rounding.



Strategic Goal 1

DISCOVER

Expand Human Knowledge through New Scientific Discoveries.

Summary of Performance for Strategic Goal 1

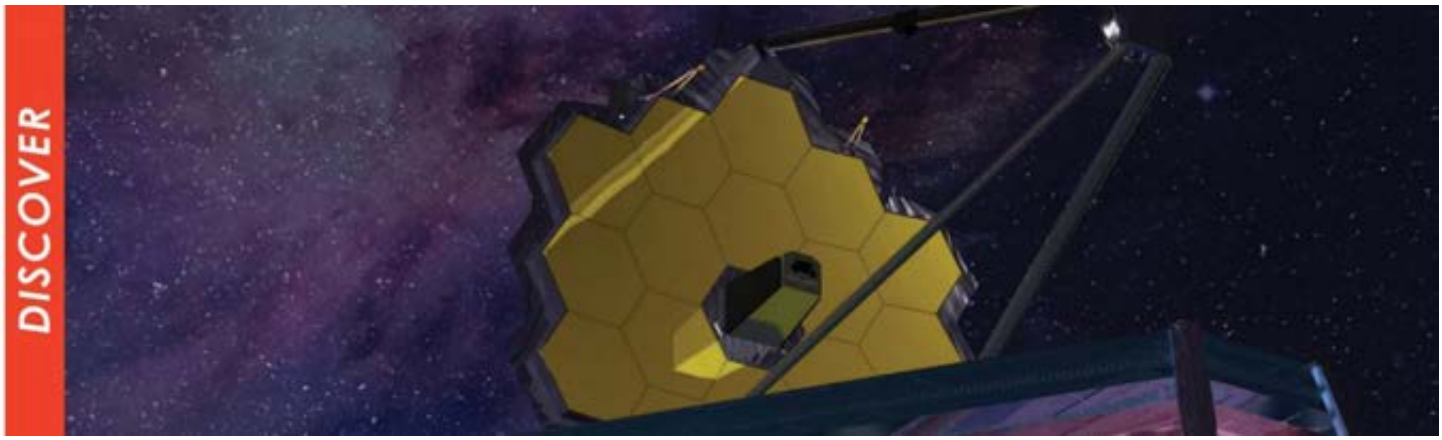
Strategic Goal 1 includes strategic objectives led by the Science Mission Directorate (SMD) and the Human Exploration and Operations Mission Directorate (HEOMD). The FY 2017 ratings are summarized below. The following pages describe performance progress for FY 2017 and provide performance plans for FY 2018 and FY 2019.

Performance Goal Ratings by Strategic Objective for FY 2017

Lead	Strategic Objective	Performance Goals				
		Total	Green	Yellow	Red	White
SMD	1.1	23	20	3	0	0
HEOMD	1.2	1	0	1	0	0
Total		**24**	**20**	**4**	**0**	**0**
Summary			**83%**	**17%**	**0%**	**0%**

Annual Performance Indicator Ratings by Strategic Objective for FY 2017

Lead	Strategic Objective	Annual Performance Indicators				
		Total	Green	Yellow	Red	White
SMD	1.1	46	39	7	0	0
HEOMD	1.2	4	3	0	1	0
Total		**50**	**42**	**7**	**1**	**0**
Summary			**84%**	**14%**	**2%**	**0%**



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

Contributing Programs/Projects:
Cosmic Origins, James Webb Space Telescope, Exoplanet Exploration, Physics of the Cosmos, Mars Exploration, Outer Planets, Astrophysics Research, Astrophysics Explorer, New Frontiers, Discovery, Planetary Defense, Planetary Research, Heliophysics Explorer, Heliophysics Research, Living With a Star, Solar Terrestrial Probes, Earth Systematic Missions, Earth System Science Pathfinder, Earth Science Research, Earth Science Multi-Mission Operations, Applied Sciences, Earth Science Technology, Planetary Technology, and Suborbital Research [budget reported as part of other programs]

Objective Overview

Discovering the Secrets of the Universe
NASA's science vision is to understand the Sun and its effects on the solar system, Earth, other planets and solar system bodies, the interplanetary environment, the space between stars in the Milky Way galaxy (the interstellar medium), and the universe beyond. NASA's journey of scientific discovery will help motivate, support, and prepare for human and robotic expansion throughout the solar system and beyond.

Searching for Life Elsewhere
"Are we alone?" is a central research question that involves biological research and research in the habitability of locations in the solar system such as Mars, the moons of outer planets, or thousands of potentially habitable worlds around other stars. This research is about a fundamental science topic at the interface of physics, chemistry, and biology.

Safeguarding and Improving Life on Earth
NASA investigates the hazards to life on Earth from the solar system, the Sun, and Earth itself. This includes understanding Earth as a system and on all time-scales. NASA also works to detect asteroids and comets, understand their composition, predict their paths, and provide timely and accurate communications about potentially hazardous objects. NASA studies the causes and effects of severe space weather events to allow for timely response. Furthermore, NASA provides data and applications for operational use by first-responders

to natural disasters, firefighters, farmers, fishermen, transportation and commerce focused organizations, weather forecasters, and others.

Strategic Objective 1.1 Data Summary

Performance Goal Ratings (1.1.1 – 1.1.24)

Fiscal Year	Total	Green	Yellow	Red	White
2017	23	20	3	0	0
2016	23	22	1	0	0
2015	23	23	0	0	0
2014	23	23	0	0	0
2013	20	20	0	0	0
2012	20	20	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	46	39	7	0	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

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.

2017 Performance Results
Green

The Heliophysics Advisory Committee (HPAC) determined in December 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. Below are examples of the scientific progress reported in FY 2017.

SOHO Reveals that the Core of the Sun Rotates Rapidly
Using data from the Solar and Heliospheric Observatory (SOHO), scientists have found long-sought evidence of seismic waves deep below the solar surface. These waves imply that the Sun's core is rotating much faster than the solar surface.

Solar scientists use helioseismology to study the interior of the Sun, just like geophysicists use regular seismology to study Earth's interior. In both cases, scientists study waves they measure at the surface to diagnose the sub-surface properties. The waves travel through the interior following curved trajectories, reflecting downward when they reach the surface, and returning later at a different location. Waves with different oscillation frequencies propagate to different depths, allowing scientists to infer how such properties as the temperature and rotation rate vary with distance from the center of the Sun. Scientists have used pressure waves, known as p-mode waves, for many years to study the layers immediately below the solar surface. Waves driven by gravity, called g-mode waves, reach much greater depths. However, they are extremely difficult to detect.

Using statistical techniques to analyze 16.5 years of data collected by SOHO's Global Oscillations at Low Frequencies (GOLF) instrument, scientists unambiguously measured elusive g-mode waves for the first time. They separated the weak signal of the g-mode waves from the strong overlapping signal from the p-mode waves. The results suggest that the Sun's core is rotating once per week, nearly four times faster than the layers above. This raises new questions about the chemical composition of the core and how layers rotating at different rates interact with each other.

MMS Measures the Physics of Magnetic Fields that Are Explosively Releasing Energy
The complex movement of electrons through space, whether they spiral, bounce, or wag back and forth, is dictated by the magnetic environment. New measurements from NASA's Magnetospheric Multiscale (MMS) mission revealed, for the first time, a new type of behavior that can explosively release large amounts of stored energy.

Magnetic reconnection is a physical process in which magnetic energy is rapidly released through breaking and remerging of magnetic field lines. It is a fundamental process that takes place in solar flares, coronal mass ejections, and at magnetic domains (magnetospheres) surrounding many of the planets in the solar system, including Earth.

Usually magnetic field lines don't break or merge with other field lines. Positively charged protons and negatively charged electrons typically move in spirals around magnetic fields; the lighter electrons have tighter spirals. When the field lines come close to each other, the pattern changes. When a magnetic field changes directions, the particles no longer make spirals—they meander instead. The small region where this occurs, called the diffusion region, is key to understanding what happens within a reconnection event.

Electrons in the diffusion region move in a hybrid, meandering motion—they spiral and bounce. The spirals become bigger until they are ejected from the region, taking some of the field's energy with them as they go. The normally difficult-to-measure ambient electric field was measured directly by filtering out high-frequency

signals. These measurements provide important insights into the physics in the electron diffusion region, and therefore what allows reconnection to occur.

Hot Hydrogen Atoms Found in the Upper Atmosphere
Earth's upper atmosphere, called the thermosphere (at an altitude of 80-500 kilometers), is the region of space that helps to support and protect life on the planet. It recycles water, absorbs the Sun's energy, and maintains a moderate temperature on Earth. This helps protect Earth from the severely cold temperatures of space. It also absorbs a large portion of the ultraviolet and X-ray radiation put off by the Sun.

Atomic hydrogen is the main element populating the upper part of the thermosphere and is key to understanding the planet's atmospheric chemistry. A comprehensive analysis of data from NASA's Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite showed that the temperature of this atomic hydrogen rises when solar activity falls, which is counter to the behavior of most other neutral molecules in the atmosphere. This contradicts simulations and fundamental theoretical assumptions that the temperature of the hydrogen atoms is controlled by interaction with atomic oxygen, which falls with declining solar activity.

These findings suggest that the influence of coupling between the atmosphere and Earth's magnetosphere, which is the region above the thermosphere and is controlled by Earth's magnetic field, has been significantly underestimated. The existence of a significant population of hot hydrogen atoms in the upper thermosphere has a profound impact on the distribution and transport of hydrogen atoms throughout the terrestrial atmosphere.

Performance Goal 1.1.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.1)

Year	Description
2018	1.1.1: Demonstrate progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.
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.

Data Quality Elements

Data Source
On an annual basis, an independent, external expert review panel from the HPAC evaluates scientific progress relative to the current science plan and assigns a rating to the annual performance indicator that supports this performance goal. 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.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.1 Annual Performance Indicators

Annual Performance Indicator 1.1.1: HE-17-1

Year	Description
Rating	Green
2017	HE-17-1: Demonstrate planned progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.
2018	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.
2019	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.

Annual Performance Indicator 1.1.1: HE-17-4

Year	Description
Rating	Green
2017	HE-17-4: Achieve Magnetospheric Multiscale (MMS) mission success criteria.
2018	No API this fiscal year.
2019	No API this fiscal year.

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.

2017 Performance Results
Green

The Heliophysics Advisory Committee (HPAC) determined in December 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. Below are examples of the scientific progress reported in FY 2017.

NASA Explores How Solar Winds Shape the Boundaries of the Solar System
Magnetic fields and sound waves near the base of the Sun's atmosphere heat and accelerate particles to supersonic speeds. The accelerated solar winds radiate outwards, affecting the entire solar system and shaping its boundaries. By carefully combining data from three different platforms, including the Solar Dynamics Observatory (SDO), Interface Region Imaging Spectrograph (IRIS), and Big Bear Solar Observatory, NASA researchers were able to determine for the first time how to track the evolution of waves through the solar wind acceleration region.

As charged particles of the solar wind reach the outer reaches of the solar system, called the heliopause, they ram into the local interstellar medium, which is the gas and dust that exists in the vast spaces between star systems. When the charged particles of solar wind collide with the neutral particles from the interstellar medium, they convert their streaming energy to heat, lose their charge, and turn into high-energy neutrals. They are then free to travel across magnetic fields back towards Earth.

Observing these neutrals, NASA's Interstellar Boundary Explorer (IBEX) mission has revealed that the solar winds emerging from the north and south poles of the Sun are not symmetric, but evolve differently. They expand and contract the north and south edges of the heliosphere asymmetrically, suggesting that the solar system's boundaries are very dynamic. Combining similar observations from NASA's Cassini mission with direct measurements of the magnetic field at the local interstellar medium from Voyager 1, researchers were able to deduce the shape of the heliopause. They revealed that it resembles a bubble, not an extended windsock-shaped object. This provides crucial information about the properties of the heliopause and the local interstellar medium, giving humans direct information about Earth's place in the cosmos.

Lower Atmosphere Waves Invade the Upper Atmosphere
A recent simulation using data from NASA's Aeronomy of Ice in the Mesosphere (AIM) and Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) missions showed that gravity waves generated by monsoons in the tropical troposphere follow a path from the tropics up to the polar summer mesosphere and affect the mesospheric temperature and frequency of polar mesospheric clouds (also called noctilucent, or "night-shining" clouds). This study shows how regional weather events on Earth are linked through gravity waves to the upper atmosphere thousands of kilometers away and across the globe.

New supercomputer models of the atmosphere are developing the spatial and temporal resolution needed to capture such links between the tropospheric weather systems and upper atmosphere and, for the first time, can simulate how waves kicked off by a cyclone in Australia propagate upward to the edge of space.

Solar Heating of the Thermosphere Determined to Be Constant Over Several Solar Cycles
With the help of NASA TIMED mission data, researchers revealed that total thermospheric radiation emitted over each solar cycle since 1947 remained relatively constant from one solar cycle to another. This implies that the total solar energy input to the thermosphere during each of these cycles was also relatively constant. This was a surprise, since the sunspot record had previously been interpreted to mean that solar energy input to the atmosphere has decreased over the past several decades.

The result challenges the fundamental theory of how the thermosphere responds to solar cycle variations. The thermosphere responds to solar and magnetospheric energy not only by cooling itself through infrared radiation, but also by emitting visible and ultraviolet light.

Performance Goal 1.1.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.2)

Year	Description
2018	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.
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.

Data Quality Elements

Data Source
On an annual basis, an independent, external expert review panel from the HPAC evaluates scientific progress relative to the current science plan and assigns a rating to the annual performance indicator that supports this performance goal. 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.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.2 Annual Performance Indicators

Annual Performance Indicator 1.1.2: HE-17-2

Year	Description
Rating	Green
2017	HE-17-2: 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.
2018	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.
2019	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.

Annual Performance Indicator 1.1.2: HE-19-5

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	HE-19-5: Achieve the Ionospheric Connection Explorer (ICON) mission success criteria.

Annual Performance Indicator 1.1.2: HE-19-8

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	HE-19-8: Based on NASA Research Announcement selections, establish Heliophysics Science Centers (HSCs) to tackle the key science problems of solar and space physics that require multidisciplinary teams of theorists, observers, modelers, and computer scientists.

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.

2017 Performance Results
Green

The Heliophysics Advisory Committee (HPAC) determined in December 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. Below are examples of the scientific progress reported in FY 2017.

Tracking Coronal Mass Ejections from the Sun to the Edge of the Heliosphere
On October 14, 2014, both a massive release of material called a coronal mass ejection (CME) and an X-ray solar flare were emitted from the Sun. An international team of scientists from the United States and Europe, including two NASA Centers, used data from 10 NASA and European Space Agency (ESA) spacecraft to track the CME from the Sun out to the edge of the solar system.

In order to understand the path the CME took through the solar system and search for more observations of the CME, the team used numerical tools available through the Community Coordinated Modeling Center (CCMC) based at the NASA Goddard Space Flight Center. Eventually, the team located the CME when it reached Venus, comet 67P/Churyumov-Gerasimenko, Mars, and Saturn. The CME kept traveling through the solar system beyond the orbit of Saturn, which is roughly 10 times the distance between the Sun and Earth, or 10 astronomical units (AU).

The search for the CME in the outer solar system was difficult because as CMEs move away from the Sun, they are worn down, sometimes even merging into one another, forming large merged interaction regions. A few months before NASA's New Horizons spacecraft reached Pluto, approximately 30 AU from the Sun, in early 2015, it observed the CME worn down and merged with adjacent solar wind structures, becoming a merged interaction region. In March 2016, the merged interaction region caused an enhancement in the dynamic pressure and a reduction in the amount of galactic cosmic ray radiation at Voyager 2, which was at 110 AU when exiting the solar system.

This work, and other recent studies, advance the understanding of how large extreme solar disturbances evolve throughout the solar system, causing space weather at each planet encountered and affecting the levels of intense harmful galactic cosmic ray radiation.

New, Faster Warnings of Dramatic Solar Storms Can Prevent Harm
Detecting intense solar storm events from the Sun, which produce hazardous conditions for human and robotic space exploration, as well as airline passengers on polar routes, is an essential part of a comprehensive radiation mitigation strategy. Observations from the COronal Solar Magnetism Observatory (COSMO) K-Coronagraph (K-Cor) at the Mauna Loa Solar Observatory, Solar Dynamics Observatory (SDO), Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI), Hinode spacecraft, and Big Bear Observatory are providing faster and more accurate warnings of CMEs and solar energetic particle events.

The K-Cor instrument is capable of detecting solar storms low in the solar corona (i.e., the Sun's upper atmosphere) at a cadence fast enough to capture the onset of an eruptive event. The January 1, 2016, CME observed by both K-Cor and the Large Angle and Spectrometric Coronagraph (LASCO) instrument on the Solar and Heliospheric Observatory (SOHO) provided a testbed to compare the performance of the new warning system against others in operation. The CME's leading edge was identified in the K-Cor images at a distance as low as 1.5 times the Sun's radius, whereas the first detection by the SOHO LASCO instrument was at 2.7 times the Sun's radius. The velocity of the CME was estimated at 1,163,207 miles-per-hour, or 520 kilometers per second (km/s), initially accelerating to 3,802,792 mph (1,700 km/s) by the time it reached

6.5 times the Sun's radius. For this test case, K-Cor produced an earlier warning than other forecast methods available currently.

A prototype warning system capability would require only modest modifications to the K-Cor observations to include software-based automated solar storm detection, measurement, and warning schemes. These new capabilities would enable the United States to issue an improved geomagnetic storm watch that would give advanced warning to astronauts and potentially allow for the rerouting of polar flights.

Performance Goal 1.1.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.3)

Year	Description
2018	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.
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.

Data Quality Elements

Data Source
On an annual basis, an independent, external expert review panel from the HPAC evaluates scientific progress relative to the current science plan and assigns a rating to the annual performance indicator that supports this performance goal. 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.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.3 Annual Performance Indicators

Annual Performance Indicator 1.1.3: HE-17-3

Year	Description
Rating	**Green**
2017	HE-17-3: 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.
2018	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.
2019	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.

Performance Goal 1.1.4

By December 2017, launch two missions in support of Heliophysics.

2017 Performance Results
Yellow

NASA is slightly behind schedule on this performance goal. NASA launched the Magnetospheric Multiscale (MMS) mission in March 2015, but delayed the launch of the Ionospheric Connection Explorer (ICON), originally planned for December 2017, until 2018.

ICON is a single spacecraft mission dedicated to exploring the boundary region between Earth and space, called the thermosphere, where ionized plasma and neutral gas collide and interact, causing dramatic variability. The mission will resolve both long-standing and newly emerging questions about the mechanisms that control the daily development of plasma in Earth's space environment. This is the region of space through which radio communications and Global Positioning System (GPS) signals travel, so variations there can result in the distortion or even complete disruption of signals.

In April 2017, ICON successfully completed its Operational Readiness Review, which evaluates the readiness of the project, ground systems, personnel, procedures, and user documentation to operate the flight system and associated ground systems in compliance with program requirements and constraints during the operations phase. This review ensured that all system and support (flight and ground) hardware, software, personnel, procedures, and user documentation accurately reflect the deployed state of the system and are operationally ready.

In July 2017, ICON successfully completed its Observatory Pre-Ship Review, which evaluates the readiness of a project to ship its spacecraft for integration with the launch vehicle.

Performance Improvement Plan

In calendar year (CY) 2017, NASA discovered a potential fault in the mechanism that will be used for the spacecraft and launch vehicle separation system. NASA postponed the launch of ICON to CY 2018 as the team investigates this issue. The revised launch readiness date is under review.

Performance Goal 1.1.4 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Yellow

Planned Future Performance (PG 1.1.4)

Year	Description
2018	1.1.4: By December 2019, launch one mission in support of Heliophysics.
2019	1.1.4: By December 2019, launch one mission in support of Heliophysics.

Data Quality Elements

Data Source

Written explanation of the rating and supporting material from the Science Mission Directorate's (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 and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.4 Annual Performance Indicators

Annual Performance Indicator 1.1.4: HE-17-5

Year	Description
Rating	**Yellow**
2017	HE-17-5: Complete Solar Probe Plus (SPP) Solar Wind Electrons Alphas and Protons (SWEAP), FIELDS, Integrated Science Investigation of the Sun (ISIS) and the Wide-Field Imager for SPP (WISPR) Pre-Ship Reviews (PSRs).
2018	HE-18-4: Launch Parker Solar Probe (PSP).
2019	No API this fiscal year.

Explanation of Rating

In FY 2017, the Solar Probe Plus was renamed the Parker Solar Probe (PSP) in honor of astrophysicist Eugene Parker. NASA completed the Pre-Ship Reviews (PSRs) for three of the four PSP instrument suites in May 2017. These include the Wide-field Imager for Solar PRobe (WISPR), the Integrated Science Investigation of the Sun (ISIS), and the Fields Experiment (FIELDS). While two of the three instruments for the Solar Wind Electrons Alphas and Protons (SWEAP) suite have also passed their PSRs and been installed on the spacecraft, multiple development issues delayed completion of the Solar Probe Cup (SPC).

The SPC is the only instrument on the Parker spacecraft that extends beyond the Thermal Protection System heat shield and is subject to an extreme solar environment, with the front surface of the SPC reaching temperatures above 1,400 degrees Celsius. The SPC team has addressed numerous thermal-related challenges, and the flight instrument completed environmental testing in October 2017.

Annual Performance Indicator 1.1.4: HE-17-6

Year	Description
Rating	**Green**
2017	HE-17-6: Complete the Ionospheric Connection Explorer (ICON) Pre-Ship Review (PSR).
2018	HE-18-8: Launch the Ionospheric Connection Explorer (ICON).
2019	No API this fiscal year.

Annual Performance Indicator 1.1.4: HE-17-7

Year	Description
Rating	**Green**
2017	HE-17-7: Complete the Step One selection for the 2016 Heliophysics Small Explorer (SMEX) Announcement of Opportunity.
2018	HE-18-5: Release the 2018 Heliophysics Medium Explorer (MIDEX) Announcement of Opportunity.
2019	HE-19-4: Complete the 2018 Heliophysics Medium Explorer (MIDEX) Announcement of Opportunity step-one selection.

Annual Performance Indicator 1.1.4: HE-17-8

Year	Description
Rating	**Green**
2017	HE-17-8: Release the Solar Terrestrial Probes -5 (STP-5) Announcement of Opportunity.
2018	HE-18-7: Complete the selection for the Interstellar Mapping and Acceleration Probe (IMAP) Announcement of Opportunity.
2019	HE-19-9: Complete Interstellar Mapping and Acceleration Probe (IMAP) concept studies.

Annual Performance Indicator 1.1.4: HE-19-6

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	HE-19-6: Complete the 2016 Heliophysics Small Explorer (SMEX) Announcement of Opportunity down-select.

Annual Performance Indicator 1.1.4: HE-19-7

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	HE-19-7: Deliver the Science and Technology Definition Team (STDT) report.

Performance Goal 1.1.5

Launch the James Webb Space Telescope. (Agency Priority Goal)

2017 Performance Results
Yellow

NASA completed the testing of the James Webb Space Telescope's (Webb's) Optical Telescope Element (OTE) plus Integrated Science Instrument Module (ISIM), together known as OTIS, in October 2018, a one-month delay. The delay in completion was due to anomalies that occurred during the vibration and acoustic testing of OTIS early in FY 2017. The additional time required to address the anomalies and resume testing in accordance with standard integration and test procedures rippled through the remaining OTIS test schedule, delaying the start of the cryovacuum testing at Johnson Space Center (JSC). Remarkably, OTIS testing was able to continue through Hurricane Harvey without incident, and the chamber warm-up commenced in late September 2017. NASA completed testing on October 21, 2017, after which the test chamber was reopened.

During FY 2017, NASA completed integration of the spacecraft bus, and also the majority of the sunshield. Subsequently, NASA completed mechanical modal testing of the combination of the spacecraft and sunshield (called the spacecraft element). One aspect of the spacecraft bus, relating to the propulsion system, is in work in parallel with other integration and test work on the spacecraft element. NASA also completed end-to-end testing between the spacecraft bus and the Mission Operations Center, via the NASA Tracking and Data Relay Satellite System (TDRSS) space network and NASA's Deep Space Network.

NASA is now planning to launch Webb during the March through June 2019 timeframe, based on an assessment of the mission's schedule of remaining integration and test activities, and coordination with the European Space Agency (ESA), which is providing the Ariane 5 launch of Webb as part of its scientific collaboration with NASA. As noted, testing of the telescope and science instruments continues to go well and is on schedule at JSC. However, the spacecraft itself, comprising the spacecraft bus and sunshield, has experienced delays during its integration and testing at Northrop Grumman in Redondo Beach, CA. While this is not indicative of hardware or technical performance concerns, the integration of the various spacecraft elements is taking longer than expected—in large part because the Webb spacecraft and sunshield are larger and more complex than most spacecraft, with some activities, such as the installation of more than 100 sunshield membrane release devices, taking longer than initially planned.

Performance Improvement Plan

The environmental testing time of the fully assembled observatory—the telescope and the spacecraft—will ensure that Webb will be fully tested before launching into space. All the rigorous tests of the telescope and the spacecraft to-date show that the mission is meeting its required performance levels.

Existing program budget accommodates the change in launch date, and the change will not affect planned science observations.

Performance Goal 1.1.5 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Yellow

Planned Future Performance (PG 1.1.5)

Year	Description
2018	1.1.5: Conduct on-orbit commissioning of the James Webb Space Telescope after launch. (Agency Priority Goal)
2019	1.1.5: Conduct on-orbit commissioning of the James Webb Space Telescope after launch. (Agency Priority Goal)

Data Quality Elements

Data Source
Emails and program-internal documents indicating progress NASA's industry partners make toward the James Webb Space Telescope integration, test and launch.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.5 Annual Performance Indicators

Annual Performance Indicator 1.1.5: JWST-17-1

Year	Description
Rating	**Yellow**
2017	JWST-17-1: Complete the testing of the James Webb Space Telescope Optical Telescope Element (OTE) plus Integrated Science Instrument Module (ISIM), known as OTIS.
2018	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.
2019	JWST-19-1: Launch the James Webb Space Telescope.

Explanation of Rating

As noted above, completion of OTIS testing moved into very early FY 2018 due to anomalies that occurred during the vibration and acoustic testing in early FY 2017. The additional month required to address the anomalies and resume testing in accordance with standard integration and test procedures rippled through the remaining test schedule, delaying the start of the cryovacuum testing.

Cryovacuum testing commenced at JSC in July 2017 and was completed in October 2017.

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.

2017 Performance Results
Green

The Astrophysics Advisory Committee (APAC) determined in July 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. Below are examples of the scientific progress reported in FY 2017.

NuSTAR Finds New Clues to "Chameleon Supernova"
NASA's Nuclear Spectroscopic Telescope Array (NuSTAR) observations of supernova SN 2014C, known as the "chameleon supernova" because it rapidly changed shape, allowed scientists to watch how the temperature of electrons accelerated by the supernova shock changed over time. They used this measurement to estimate how fast the supernova expanded and how much material is in the external shell. NASA's Chandra X-ray Observatory and Swift observatory were also used to further assess the evolution of the supernova. Surprisingly, the supernova brightened in X-rays after the initial explosion, demonstrating that there must have been a shell of material previously ejected by the star that the shock waves had hit.

Leading theories include that there is something missing in humankind's understanding of the nuclear reactions that occur in the cores of massive, supernova-prone stars.

Astronomers Discover Powerful Cosmic Double Whammy
Using data from NASA's Chandra X-ray Observatory and several other telescopes, astronomers discovered a cosmic one-two punch unlike any ever seen in a pair of colliding galaxy clusters, Abell 3411 and Abell 3412. This shows that an eruption from a supermassive black hole combined with a galaxy cluster merger can create a stupendous cosmic particle accelerator.

First, at least one spinning, supermassive black hole in one of the galaxy clusters produced a rotating, tightly-wound magnetic funnel. The powerful electromagnetic fields associated with this structure accelerated the inflowing gas away from the vicinity of the black hole in the form of an energetic, high-speed jet.

Then, these accelerated particles in the jet were accelerated again when they encountered colossal shock waves, produced by the collision of the massive gas clouds associated with the galaxy clusters.

Astronomers Pursue Renegade Supermassive Black Hole
Using data from NASA's Chandra X-ray Observatory, Hubble Space Telescope, and other telescopes, astronomers recently hunted down what could be a supermassive black hole that may be on the move.

This possible renegade black hole, which contains about 160 million times the mass of the Sun, is located in an elliptical galaxy about 3.9 billion light years from Earth. Astronomers are interested in these moving supermassive black holes because they may reveal more about the properties of these enigmatic objects.

This black hole may have "recoiled," in the terminology used by scientists, when two smaller supermassive black holes collided and merged to form an even larger one. At the same time, this collision would have generated gravitational waves that emitted more strongly in one direction than others. This newly formed black hole could have received a kick in the opposite direction of those stronger gravitational waves. This kick would have pushed the black hole out of the galaxy's center.

The strength of the kick depends on the rate and direction of spin of the two smaller black holes before they merge. Therefore, information about these important but elusive properties can be obtained by studying the speed of recoiling black holes.

Performance Goal 1.1.6 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.6)

Year	Description
2018	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.
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.

Data Quality Elements

Data Source
On an annual basis, an independent, external expert review panel from the APAC evaluates scientific progress relative to the current science plan and assigns a rating to the annual performance indicator that supports this performance goal. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.6 Annual Performance Indicators

Annual Performance Indicator 1.1.6: AS-17-1

Year	Description
Rating	Green
2017	AS-17-1: Demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.
2018	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.
2019	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.

Performance Goal 1.1.7

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

2017 Performance Results
Green

The Astrophysics Advisory Committee (APAC) determined in July 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. Below are examples of the scientific progress reported in FY 2017.

Observatories Combine to Crack Open the Crab Nebula
Using data from NASA's Chandra X-ray Observatory, Hubble Space Telescope, and Spitzer Space Telescope, combined with ground-based radio observations, astronomers produced a highly-detailed image of the Crab Nebula, the result of a bright supernova explosion 6,500 light-years from Earth, seen by Chinese and other astronomers in the year 1054. At its center is a super-dense neutron star, rotating once every 33 milliseconds, shooting out rotating lighthouse-like beams of radio waves and light—a pulsar. The nebula's intricate shape is caused by a complex interplay of the pulsar, a fast-moving wind of particles coming from the pulsar, and material originally ejected by the supernova explosion and by the star itself before the explosion.

Hubble Space Telescope Uncovers a Galaxy Pair Coming in from the Wilderness
Hubble Space Telescope observations of two dwarf galaxies, Pisces A and B, suggest they are late bloomers because they spent most of their existence in the Local Void, a region of the universe sparsely populated with galaxies.

Under the steady pull of gravity from the other galaxies, the dwarf galaxies entered a crowded region that is denser in intergalactic gas. In this gas-rich environment, star birth may have been triggered by gas raining down on the galaxies as they plowed through the denser region. Alternatively, the duo may have encountered a gaseous filament, which compresses gas in the galaxies and stokes star birth. Dwarf galaxies are the building blocks from which larger galaxies were formed billions of years ago in the early universe. Inhabiting a sparse desert of largely empty space for most of the universe's history, these two galaxies avoided that busy construction period.

"Kitchen Smoke" Molecules in Nebula Offer Clues to the Building Blocks of Life
Using data collected by NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) and other observatories, an international team of researchers has studied how a particular type of organic molecule, the raw materials for life, could develop in space. This information may help scientists better understand how life could have developed on Earth.

The team focused on a type of molecule called polycyclic aromatic hydrocarbons (PAHs), which are flat molecules consisting of carbon atoms arranged in a honeycomb pattern, surrounded by hydrogen. PAHs make up about 10 percent of the carbon in the universe, and are found on Earth, where they are released upon the burning of organic material such as meat, sugarcane, and wood. The team determined that when PAHs in the nebula NGC 7023, also known as the Iris Nebula, are hit by ultraviolet radiation from the nebula's central star, they evolve into larger, more complex molecules. Scientists hypothesize that the growth of complex organic molecules like PAHs is one of the steps leading to the emergence of life.

Performance Goal 1.1.7 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.7)

Year	Description
2018	1.1.7: Demonstrate progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.
2019	1.1.7: Demonstrate progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.

Data Quality Elements

Data Source
On an annual basis, an independent, external expert review panel from the APAC evaluates scientific progress relative to the current science plan and assigns a rating to the annual performance indicator that supports this performance goal. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.7 Annual Performance Indicators

Annual Performance Indicator 1.1.7: AS-17-2

Year	Description
Rating	**Green**
2017	AS-17-2: Demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.
2018	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.
2019	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.

Annual Performance Indicator 1.1.7: AS-19-3

Year	Description
Rating	**Green**
2017	AS-17-3: Complete Stratospheric Observatory for Infrared Astronomy (SOFIA) third-generation instrument Critical Design Review (CDR).
2018	No API this fiscal year.
2019	AS-19-3: Deliver Stratospheric Observatory for Infrared Astronomy (SOFIA) third-generation High Resolution Mid-Infrared Spectrometer (HIRMES) instrument.

Performance Goal 1.1.8

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

2017 Performance Results
Green

The Astrophysics Advisory Committee (APAC) determined in July 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. Below are examples of the scientific progress reported in FY 2017.

NASA Telescope Reveals Largest Batch of Earth-Size, Habitable-Zone Planets around Single Star
NASA's Spitzer Space Telescope revealed the first known system of seven Earth-size planets around a single star. Three of these planets are located in the habitable zone, the area around the parent star where a rocky planet is most likely to have liquid water.

The discovery sets a new record for greatest number of habitable-zone planets found around a single star outside of the solar system. All seven of these planets could have liquid water under the right atmospheric conditions, but chances are highest with the three in the habitable zone.

At about 40 light-years (235 trillion miles) from Earth, the system of planets is relatively close, in the constellation Aquarius. This exoplanet system is called TRAPPIST-1, named for the TRAnsiting Planets and PlanetesImals Small Telescope (TRAPPIST) in Chile.

Small Planets Come in Two Sizes
Using Kepler spacecraft data, researchers found two distinct size groupings of small planets. This result could have significant implications for the search for life. This discovery shows that about half the known planets in the galaxy either have no surface, or lie beneath a deep, crushing atmosphere–an environment unlikely to host life. The team found a clean division in the sizes of rocky, Earth-size planets and gaseous planets smaller than Neptune. Few planets were found between those groupings.

It seems that nature commonly makes rocky planets up to about 75 percent bigger than Earth. For reasons not yet understood, half of those planets take on a small amount of hydrogen and helium that dramatically swells their size, allowing them to “jump the gap” and join the population closer to Neptune’s size.

NASA Releases Kepler Survey Catalog with Hundreds of New Planet Candidates
On June 19, 2017, NASA’s Kepler space telescope team released a mission catalog of planet candidates that introduces 219 new candidates, 10 of which are near Earth-size and orbiting in their star's habitable zone, which is the range of distance from a star where liquid water could pool on the surface of a rocky planet.

This is the most comprehensive and detailed catalog release of candidate exoplanets, which are planets outside the solar system, from Kepler’s first four years of data. It’s also the final catalog from the spacecraft’s view of the patch of sky in the Cygnus Constellation.

With the release of this catalog, derived from data publicly available on the NASA Exoplanet Archive, there are now 4,034 planet candidates identified by Kepler. Of those, 2,335 have been verified as exoplanets. Of roughly 50 near-Earth size habitable zone candidates detected by Kepler, more than 30 have been verified.

Performance Goal 1.1.8 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.8)

Year	Description
2018	1.1.8: Demonstrate progress in discovering and studying planets around other stars and exploring whether they could harbor life.
2019	1.1.8: Demonstrate progress in discovering and studying planets around other stars and exploring whether they could harbor life.

Data Quality Elements

Data Source
On an annual basis, an independent, external expert review panel from the APAC evaluates scientific progress relative to the current science plan and assigns a rating to the annual performance indicator that supports this performance goal. Their findings are available online at https://science.nasa.gov/researchers/nac/science-advisory-committees/. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.8 Annual Performance Indicators

Annual Performance Indicator 1.1.8: AS-17-5

Year	Description
Rating	**Green**
2017	AS-17-5: Demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life.
2018	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.
2019	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.

Performance Goal 1.1.9

By December 2018, launch at least one mission in support of Astrophysics.

2017 Performance Results
Green

In support of this performance goal, NASA continued work on the Transiting Exoplanet Survey Satellite (TESS), which will use an array of telescopes to perform the first-ever spaceborne all-sky exoplanet transit survey. TESS will look 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.

TESS instrument and spacecraft integration were completed in summer 2017, and both the TESS Systems Integration Review (SIR) and the Key Decision Point (KDP)-D were successfully completed in July 2017 and August 2017, respectively. KDP-D is a major gatekeeping review held to determine the readiness of a project to move from final design and fabrication to system assembly, integration, test, and launch. The TESS Observatory completed environmental testing in December 2017. TESS is scheduled to be shipped to the Kennedy Space Center in early February 2018 to support a launch no earlier than March 20, 2018.

Performance Goal 1.1.9 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Green

Planned Future Performance (PG 1.1.9)

Year	Description
2018	1.1.9: By December 2018, launch at least one mission in support of Astrophysics.
2019	1.1.9: By December 2021, launch one mission in support of Astrophysics.

Data Quality Elements

Data Source
Written explanation of the rating and supporting material from the Science Mission Directorate's (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 and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.9 Annual Performance Indicators

Annual Performance Indicator 1.1.9: AS-17-4

Year	Description
Rating	**Green**
2017	AS-17-4: Complete the Transiting Exoplanet Survey Satellite (TESS) System Integration Review (SIR).
2018	AS-18-7: Launch the Transiting Exoplanet Survey Satellite (TESS).
2019	No API this fiscal year.

Annual Performance Indicator 1.1.9: AS-17-6

Year	Description
Rating	**Yellow**
2017	AS-17-6: Complete Wide-Field Infrared Survey Telescope (WFIRST) System Requirements Review (SRR).
2018	AS-18-5: Complete Wide-Field Infrared Survey Telescope (WFIRST) Key Decision Point (KDP)-B.
2019	No API this fiscal year.

Explanation of Rating

NASA has chartered a WFIRST Independent External Technical/Management/Cost Review (WIETR) in response to a specific recommendation by the National Academies in its report, *New Worlds, New Horizons: A Midterm Assessment*. The System Requirements Review and Mission Definition Review (SRR/MDR) has been delayed to allow any findings from the WIETR to be incorporated.

WFIRST is proposed for elimination in the FY 2019 President's budget request.

Annual Performance Indicator 1.1.9: AS-17-7

Year	Description
Rating	**Green**
2017	AS-17-7: Complete the 2016 Astrophysics Medium Explorer (MIDEX) Step One selection.
2018	AS-18-6: Complete concept studies for the 2016 Astrophysics Medium Explorer (MIDEX) Announcement of Opportunity.
2019	AS-19-6: Complete the 2016 Astrophysics Medium Explorer (MIDEX) Announcement of Opportunity down-select.

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.

2017 Performance Results
Green

The Planetary Science Advisory Committee (PAC) determined in October 2017 that NASA remained on track in its annual performance supporting achievement of this performance goal. Below are examples of the scientific progress reported in FY 2017.

Surface Water Ice in Lunar Polar Regions
Water ice in lunar polar regions may provide valuable resources for planetary exploration, such as for life support and as propellant to fuel exploration. Finding water can enable exploration by reducing the amount of material launched from Earth. The Lunar Orbiter Laser Altimeter (LOLA) on the Lunar Reconnaissance Orbiter (LRO) shines laser light on the Moon's surface and observes the reflected light. Water ice has a higher reflectivity than lunar regolith. The more reflective surfaces also correlate to regions previously identified to be potential exposed frost on the surface by LRO Lyman-Alpha Mapping Project (LAMP) data. The datasets from LRO all indicate that water ice is exposed in regions near the lunar south pole, where the temperature is cold enough for water ice to be stable on the surface.

Aeolian Activity in Gale Crater
Wind has modified the landscapes on Mars for billions of years, and continues to do so, despite the low-density atmosphere. Data from the Curiosity Rover and the Mars Reconnaissance Orbiter are helping scientists form a more complete understanding of the effect of wind in Gale Crater. Major wind circulation patterns in Gale Crater reconstructed from wind-sculpted features at the surface show how regional and slope winds eroded the central mound.

New Views of Occator Crater Reveal Complex Processes
The 92-kilometer Occator Crater on Ceres hosts deposits of bright material rich in sodium carbonate. The lack of smaller craters within Occator indicates that the floor material is relatively young, although researchers have determined that the crater itself is about 90 million years old. A topographic model using data from the Dawn mission revealed a complex structure with the bright deposits located in a central depression. The material observed at the top of the central dome has also been found in the crater walls. The central pit is surrounded by a dense network of faults, suggesting tectonic uplift is involved in the long-term evolution of the dome. These observations indicate that the bright deposits have been emplaced recently.

Juno's First Glimpse of Jupiter's Complexity
Last year, the Juno spacecraft approached Jupiter on the planet's dawn flank and entered into Jupiter's orbit. Juno began making polar passes close to the planet, probing beneath the obscuring cloud cover, and transmitting the data back to Earth. First results hint that Jupiter may not have a distinct core and indicate puzzling deep atmospheric convection. They also reveal complex small-scale structure in the magnetic field and auroral processes that are distinctly different from those at Earth.

Cassini Observations of Ice Grains Emitted from Enceladus's Tiger Stripes
Saturn's moon Enceladus hosts an ice-covered ocean. Eruptions of plumes of ice grains and gas, emitting from long cracks in the icy shell covering the southern polar region, provide glimpses into the content of the ocean. Scientists examined data collected by NASA's Cassini spacecraft about the ice content of plumes from different cracks. Data show the grains to be predominately water ice in crystalline form, which constrains the temperature of the region where the ice grains form. Data also provide the size distribution of particles and how it varies from one fissure to another. This is important in the planning of future missions that might sample the plumes to seek evidence for habitability or life.

Pluto's Global Surface Composition Mapped by New Horizons
Data from the Ralph instrument's Linear Etalon Imaging Spectral Array (LEISA) infrared imaging spectrograph on the New Horizons mission helped obtain compositional maps of Pluto's volatile and non-volatile components. Results have shown that variations of methane and nitrogen ices are driven by differences in insolations, which is the amount of solar radiation reaching the planet's surface in a given area. Over the past few decades, increased insolation at Pluto's north pole has sublimated most of the volatile nitrogen into the atmosphere, where it is transported and recondensed southward. Data have also shown possible sublimation transport of nitrogen ice within Sputnik Planitia.

Performance Goal 1.1.10 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.10)

Year	Description
2018	1.1.10: Demonstrate progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.
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.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.10 Annual Performance Indicators

Annual Performance Indicator 1.1.10: PS-17-1

Year	Description
Rating	**Green**
2017	PS-17-1: Demonstrate planned progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.
2018	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.
2019	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.

Performance Goal 1.1.11

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

2017 Performance Results
Green

The Planetary Science Advisory Committee (PAC) determined in October 2017 that NASA remained on track in its annual performance supporting achievement of this performance goal. Below are examples of the scientific progress reported in FY 2017.

Lake Superior-Sized Ice Deposit on Mars
The Mars Reconnaissance Orbiter (MRO) has identified a region of Mars, called Utopia Planitia, that has significant amounts of subsurface ice. MRO's ground-penetrating Shallow Radar (SHARAD) instrument indicated that the cracked and pitted plains of this region contain as much water as Lake Superior here on Earth. Water cannot persist at this latitude at the surface of Mars today, but this deposit is buried between a layer of Martian regolith that is between 1 to 10 meters thick. This material has a distinctive texture, including scalloped pits and polygonal cracking that, in the Canadian Arctic, is usually indicative of ground ice. Identifying this ice deposit has nearly doubled the known volume of ice in the northern plains of Mars. NASA considers this source of water to be a potential resource for future human exploration.

HiRISE Data Show Water-Rich Flows over Region around Hale Crater
Hale Crater, an ice-rich terrain, is one of the youngest, largest (roughly 125 kilometers across), and best-preserved craters on Mars. Data from MRO's High-Resolution Imaging Science Experiment (HiRISE) show that discontinuous, initially water-rich deposits up to 450 kilometers from Hale's rim were ballistically emplaced and flowed for hours up to a day or two after impact. The pristine nature of these deposits indicates that erosion rates were low after the Hale impact and that the crater formed after regional alluvial fans, sloping layers of sediment deposited by flowing water. The deposits also show that crater formation did not influence global or regional scale geomorphic activity or climate for any extended period of time.

Past Rain on Mars
Features preserved from different time periods on Mars show distinctly different weathering patterns that, for the first time, have been linked to the changing nature of rainfall as the Martian atmosphere waned. As the surface of Mars preserves vast expanses of terrain from the earliest parts of its history, features such as modified impact craters, valley networks, and fluvial sedimentary deposits have been preserved for more than four billion years in some places. These features show definitive modification by water, but in different ways for features of different ages. Data from the Mars Orbiter Laser Altimeter (MOLA) were used to understand how different atmospheric pressures could affect the weathering of features on Mars's surface.

Cassini Images Determine Depth of Ligeia Mare, Titan's Hydrocarbon Lake
Scientists have been able to estimate both the depth and volume of Titan's lakes and seas using data from Cassini's radar instrument. The lakes and seas are composed primarily of methane. On Earth, methane is gaseous at ambient temperatures, while on Titan it is far more abundant and commonly found in both gaseous and liquid forms. Collectively, the volume of liquid hydrocarbon exposed on Titan is equivalent to 35 times the mass of Earth's fossil fuel reserves and 300 times the mass of Earth's proven natural gas reserves. In addition, the lakes and seas hold only a fraction of Titan's total hydrocarbon stockpile—the atmosphere holds seven times more. The source of methane in Titan's atmosphere and lakes is a mystery at this time. However, Cassini's determination of the methane abundance of Titan's lakes provides an important clue to its possible origins.

Performance Goal 1.1.11 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.11)

Year	Description
2018	1.1.11: Demonstrate progress in exploring and observing the objects in the solar system to understand how they formed and evolve.
2019	1.1.11: Demonstrate progress in exploring and observing the objects in the solar system to understand how they formed and evolve.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.11 Annual Performance Indicators

Annual Performance Indicator 1.1.11: PS-17-2

Year	Description
Rating	Green
2017	PS-17-2: Demonstrate planned progress in exploring and observing the objects in the solar system to understand how they formed and evolve.
2018	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.
2019	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.

Annual Performance Indicator 1.1.11: PS-18-11

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	PS-18-11: Complete Juno mission success criteria.
2019	No API this fiscal year.

Annual Performance Indicator 1.1.11: PS-18-12

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	PS-18-12: Complete Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer (OSIRIS-Rex) arrival at the Bennu asteroid.
2019	No API this fiscal year.

Annual Performance Indicator 1.1.11: PS-19-3

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	PS-19-3: Complete New Horizons first-ever flyby of a Kuiper Belt Object (2014MU69).

Performance Goal 1.1.12

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

2017 Performance Results
Green

The Planetary Science Advisory Committee (PAC) determined in October 2017 that NASA remained on track in its annual performance supporting achievement of this performance goal. Below are examples of the scientific progress reported in FY 2017.

Habitable Environments Mapped in Candor Chasma on Mars
To further understanding of the structural and depositional history of Candor Chasma in the Valles Marineris region of Mars, three large-scale (1:18,000) structural and geologic maps were constructed using images and digital models from the Mars Reconnaissance Orbiter's (MRO's) High-Resolution Imaging Science Experiment (HiRISE). The oldest rocks found in the Eastern Candor Sulci and Southeastern Ceti Mensa areas formed as sand sheets in a wet playa environment dominated by shallow pools, which trapped wind-blown dust that ultimately formed the rock layers now visible. The youngest rocks, exposed in the Western Ceti Mensa area, show a transition from sand sheets to sand dunes, signaling a shift toward an increasingly arid environment. The wet playa setting may have served as a habitable environment. Sediments associated with this environment are prime targets for the search for evidence of past life on Mars.

Gale Crater: Extended Period of Habitability on Ancient Mars
The sedimentary rock record explored in Aeolis Palus and in the lower slopes of Aeolis Mons using the Curiosity rover is interpreted to be that of streams and lakes that persisted for millions of years. Data from Curiosity show that the more than 200 vertical meters of the Murray Formation section consist primarily of laminated mudstones that formed in lakes, with minor intervals of river or dry conditions. A comparison with depositional rates in terrestrial lake basins suggests that lakes were present within Gale Crater for millions of years. Together, these observations show that the climate of equatorial Mars during the early Hesperian period, when the geology had increased volcanic activity, was consistently warm and humid enough to allow liquid water to saturate the surface and subsurface of Gale Crater. Liquid water eroded the surface, transporting sediment, and recharged lakes as part of a hydrological cycle. The mudstone shows variations in chemical composition that may indicate stratification within the water column, with more oxygen available nearer to the surface, or may be the recorded effects of later groundwater circulations.

Cassini Finds Molecular Hydrogen in the Enceladus Plume: Evidence of Hydrothermal Processes and Energy for Life
Saturn's moon Enceladus has a subsurface ocean covered by a layer of ice. Some liquid escapes into space through cracks in the ice, which is the source of one of Saturn's rings. In October 2015, NASA's Cassini spacecraft flew directly through the plume of escaping material and sampled its chemical composition. Researchers found that the plume contains molecular hydrogen, a sign that the water in Enceladus's ocean is reacting with rocks through hydrothermal processes. This reaction drives the ocean out of chemical equilibrium, in a similar way to water around Earth's hydrothermal vents, potentially providing a source of chemical energy, an important factor for habitability.

Performance Goal 1.1.12 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.12)

Year	Description
2018	1.1.12: Demonstrate progress in exploring and finding locations where life could have existed or could exist today.
2019	1.1.12: Demonstrate progress in exploring and finding locations where life could have existed or could exist today.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.12 Annual Performance Indicators

Annual Performance Indicator 1.1.12: PS-17-3

Year	Description
Rating	Green
2017	PS-17-3: Demonstrate planned progress in exploring and finding locations where life could have existed or could exist today.
2018	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.
2019	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.

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.

2017 Performance Results
Green

The Planetary Science Advisory Committee (PAC) determined in October 2017 that NASA remained on track in its annual performance supporting achievement of this performance goal. Below are examples of scientific progress that were supported by NASA and reported in FY 2017.

Evidence for Earliest Life in Earth's Oldest Rocks
Although it is not known when or where life on Earth began, two recent reports describe putative microfossils. Geologists have discovered in Greenland evidence for ancient life in rocks that are 3.7 billion years old. The fossils were part of an outcrop of ancient rock that had lost its usual snow cover. The rock layer forming the outcrop, known to geologists as the Isua supracrustal belt, lies on the southwest coast of Greenland and is some 3.7 to 3.9 billion years old. A second line of evidence came from what is thought to be some of the earliest habitable environments, submarine-hydrothermal vents. Astrobiologists have found putative fossilized microorganisms that are at least 3.77 billion and possibly 4.28 billion years old in ferruginous sedimentary rocks, interpreted as seafloor-hydrothermal vent-related precipitates, from the Nuvvuagittuq Greenstone Belt in Quebec, Canada. These structures occur as micrometer-scale tubes and filaments with morphologies and mineral assemblages similar to those of filamentous microorganisms from modern hydrothermal vent precipitates and analogous microfossils in younger rocks. The Nuvvuagittuq rocks contain isotopically light carbon in carbonate and carbonaceous material associated with the putative microfossils and provide evidence for biological activity in submarine-hydrothermal environments more than 3.77 billion years ago.

Taking Earth's Subsurface Temperature
Approximately three hundred million cubic kilometers of ocean sediment is saturated with eighty million cubic kilometers of porewater that is inhabited by an estimated three hundred nonillion (3×10^{29}) microbial cells. Several global datasets (e.g., sediment thickness, bathymetry, heat flow, and bottom water temperatures) were combined with modeling efforts to calculate the three-dimensional distribution of temperature in marine sediments. More than 75 percent of the volume of Earth's marine sediments are above 80 degrees Celsius. This temperature is at or near the upper limit of where microbial metabolism plays an important role in the subsurface. In other words, on Earth there is microbial life in maritime sediment that survives and prospers under very specific conditions. Understanding these conditions helps in the search for extraterrestrial life.

Evolution of a Global Phosphorus Cycle
Phosphorus is thought to limit primary biological productivity in the oceans over geological timescales. Phosphorus in shallow waters increased around 800 million years ago, at the same time as a significant upward spike in oxygen content of the oceans and atmosphere. This timing suggests that phosphorus scarcity and then relative abundance may also explain the long-delayed oxygenation of Earth's surface. At the same time, as a possible consequence, complex life such as algae exploded in the oceans for the first time—followed not long after by the rise of animals. Such fundamental biogeochemical cycles may be required for life to originate and develop on any planet.

Lichens Are Not What They Seem
Lichens are globally critical organisms found within weathering rocks where few other organisms can live (e.g., the highest mountains in the world). For almost 150 years, lichens have been thought to be composed of a fungus partner and a photosynthetic microorganism or algae partner. Now it has been discovered that a third partner, a yeast organism, is also participating in this important geobiological symbiosis, and has been found in a wide variety of habitats on six continents.

Performance Goal 1.1.13 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.13)

Year	Description
2018	1.1.13: Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.
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.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.13 Annual Performance Indicators

Annual Performance Indicator 1.1.13: PS-17-4

Year	Description
Rating	Green
2017	PS-17-4: Demonstrate planned progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.
2018	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.
2019	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.

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.

2017 Performance Results
Green

The Planetary Science Advisory Committee (PAC) determined in October 2017 that NASA remained on track in its annual performance supporting achievement of this performance goal. Below are examples of the progress reported in FY 2017.

NASA's Planetary Defense Coordination Office
NASA and its partners maintain a watch for near-Earth objects (NEOs), asteroids and comets that pass within Earth's neighborhood, as part of an ongoing effort to discover, catalog, and characterize these bodies. NEOs range in size from a few meters to approximately 34 kilometers in size, with smaller objects being two orders of magnitude more numerous than larger objects.

On January 6, 2016, NASA announced the establishment of its Planetary Defense Coordination Office (PDCO), managed in the Planetary Science Division. The PDCO includes the ongoing Near-Earth Object Observations (NEOO) Program. The NEOO Program coordinates NEO observation efforts conducted at ground-based observatories sponsored by the National Science Foundation and space situational awareness facilities of the U.S. Air Force. In addition to finding, tracking, and characterizing NEOs, NASA's planetary defense goals include developing techniques for deflecting or redirecting, if possible, potentially hazardous objects that are determined to be on an impact course with Earth. In the event that deflection or redirection is not possible, the PDCO is responsible for providing expert advice to the Federal Emergency Management Agency (FEMA) for emergency response operations should a potentially hazardous object be on an impact course or actually impact Earth.

In FY 2017, asteroid search teams funded by NASA's NEOO Program found seven asteroids larger than one kilometer in size with orbits that can come within Earth's vicinity. Asteroid search teams also found 1,621 smaller asteroids less than one kilometer in size. This brings the total known population of near-Earth asteroids to 16,512 as of September 1, 2017. The high-precision orbit predictions computed by the NASA Center for Near-Earth Object Studies show that none of these objects is likely to strike Earth in the next century. However, 1,831 small bodies (of which 157 are larger than one kilometer in diameter), with 106 near-Earth comets, are in orbits that could become a hazard in the more distant future and warrant continued monitoring.

In the NASA Authorization Act of 2005, Congress directed NASA to find 90 percent of the near-Earth objects down to 140 meters in size by 2020. As of September 1, 2017, 7,782 near-Earth asteroids with sizes greater than 140 meters have been discovered and catalogued. Models estimate that there are approximately 25,000 near-Earth asteroids larger than 140 meters in size, which leaves roughly 68 percent of the population yet to be discovered after almost 20 years of NEO search efforts. These priorities were reiterated in the NASA Authorization Act of 2017, in which Congress directed NASA to expand its efforts to include potentially hazardous NEOs less than 140 meters in size, and to leverage the capabilities of the private sector and philanthropic organizations in its search, to the extent practicable.

Kilometer-Sized Asteroid Makes a Close Approach to Earth
On April 19, 2017, the potentially hazardous asteroid 2014 JO25 approached Earth at less than 4.6 times the distance to the Moon (1.8 million kilometers). Discovered in 2014 by the Catalina Sky Survey, it was studied by other projects in the NEOO Program of the PDCO during its approach. Data showed it to be approximately 950 meters long. Its asymmetric, two-lobed structure might indicate a contact binary and is reminiscent of comet 67P/Churyumov-Gerasimenko.

The elongated orbit of JO25, dipping below the plane of the solar system, is also not unlike a comet's orbit. However, initial results from NASA's Infrared Telescope Facility reveal a spectrum similar to that of ordinary chondrites, the most common group of meteorites found on Earth.

This type of NEO is difficult for the current ground-based optical surveys to detect and observe for two major reasons. First, it has a highly elliptical orbit, with high velocity through the inner solar system. Second, it approached Earth from the direction of the Sun, so ground-based telescopes could not see it until after it crossed Earth's orbit. If an object of this size (approximately one kilometer) and velocity (33 kilometers per second) were to impact Earth, it could result in a crater 10 kilometers or more in size, with a much wider area of devastation from the blast and possible global effects on climate caused by ejecta.

Performance Goal 1.1.14 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.14)

Year	Description
2018	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.
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.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.14 Annual Performance Indicators

Annual Performance Indicator 1.1.14: PS-17-5

Year	Description
Rating	**Green**
2017	PS-17-5: 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.
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.
2019	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.

Annual Performance Indicator 1.1.14: PS-17-9

Year	Description
Rating	**Green**
2017	PS-17-9: Demonstrate planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or other resources for human exploration.
2018	PS-18-6: As determined by the Planetary Science Advisory Committee (PAC), demonstrated planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.
2019	PS-19-6: As determined by the Planetary Science Advisory Committee (PAC), demonstrated planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.

Annual Performance Indicator 1.1.14: PS-18-12

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	PS-18-12: Identify and catalog a cumulative 8,400 of the estimated 25,000 near-Earth asteroids (NEAs) 140 meters or larger.
2019	PS-19-13: Identify and catalog a cumulative 9,000 of the estimated 25,000 near-Earth asteroids (NEAs) 140 meters or larger.

Performance Goal 1.1.15

Does not trend until FY 2018.

2017 Performance Results
N/A

This is a new performance goal in FY 2018.

Performance Goal 1.1.15 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 1.1.15)

Year	Description
2018	1.1.15: Deliver the Mars 2020 instrument payload for spacecraft integration. (Agency Priority Goal)
2019	1.1.15: Deliver the Mars 2020 instrument payload for spacecraft integration. (Agency Priority Goal)

Data Quality Elements

Data Source
Emails, press releases, and program-internal documents indicating progress toward integration, test, and launch.

Verification and 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 contributing partners, and other program-internal documents.

Data Limitations
Data are sufficiently accurate for their intended use. Materials may include export-controlled technical information or industrial partner proprietary information, which could not be released publicly.

Performance Goal 1.1.15 Annual Performance Indicators

Annual Performance Indicator 1.1.15: PS-17-8

Year	Description
Rating	Green
2017	PS-17-8: Complete the Mars 2020 Critical Design Review (CDR)
2018	PS-18-7: Complete the Mars 2020 System Integration Review (SIR).
2019	PS-19-7: Deliver Mars 2020 instrument payload to Assembly, Test, and Launch Operations (ATLO).

Performance Goal 1.1.16

By December 2017, launch at least two missions in support of Planetary Science.

2017 Performance Results
Green

NASA achieved this performance goal with the successful launch of two Planetary Science missions, including the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft in November 2013 and the Origins, Spectral Interpretation, Resource Identification, and 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 the role that loss of volatiles (substances that evaporate quickly) from the Mars atmosphere to space has played through time, giving insight into the history of Mars's atmosphere and climate, liquid water, and planetary habitability. 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 will travel to Bennu, a near-Earth asteroid, and bring a small sample back to Earth for study. In September 2017, OSIRIS-REx completed a flyby of the Earth in order to use the Earth's gravitational field to slingshot it towards Bennu. The spacecraft will reach its asteroid target in 2018 and return the sample to Earth in 2023. The sample will provide insight into the composition of the very early solar system, the source of organic materials and water that made life possible on Earth, and to better predict the orbits of asteroids that represent collision threats to Earth.

Performance Goal 1.1.16 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Green

Planned Future Performance (PG 1.1.16)

Year	Description
2018	1.1.16: By December 2017, launch at least two missions in support of Planetary Science.
2019	1.1.16: By December 2021, launch one mission in support of Planetary Science.

Data Quality Elements

Data Source
Written explanation of the rating and supporting material from the Science Mission Directorate's (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 and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.16 Annual Performance Indicators

Annual Performance Indicator 1.1.16: PS-17-6

Year	Description
Rating	**Green**
2017	PS-17-6: Launch the Origins, Spectral Interpretation, Resource Identification, and Security Regolith (OSIRIS-Rex) mission.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 1.1.16: PS-17-10

Year	Description
Rating	**Green**
2017	PS-17-10: Release New Frontiers 4 Announcement of Opportunity (AO).
2018	PS-18-8: Complete New Frontiers 4 Step One Selection.
2019	PS-19-9: Complete New Frontiers 4 down-select.

Annual Performance Indicator 1.1.16: PS-17-11

Year	Description
Rating	**Green**
2017	PS-17-11: Complete down-select for Discovery 13 mission.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 1.1.16: PS-17-12

Year	Description
Rating	**Green**
2017	PS-17-12: Complete Europa Key Decision Point-B (KDP-B).
2018	PS-18-10: Complete Europa Instrument Preliminary Design Reviews (PDRs).
2019	PS-19-8: Complete Europa Clipper Key Decision Point (KDP)-C.

Annual Performance Indicator 1.1.16: PS-18-13

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	PS-18-13: Launch the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission.
2019	No API this fiscal year.

Annual Performance Indicator 1.1.16: PS-19-10

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	PS-19-10: Complete the Lucy mission Key Decision Point (KDP)-C.

Annual Performance Indicator 1.1.16: PS-19-11

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	PS-19-11: Complete the Psyche mission Preliminary Design Review (PDR).

Annual Performance Indicator 1.1.16: PS-18-14

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	PS-18-14: Complete the Double Asteroid Redirection Test (DART) Preliminary Design Review (PDR).
2019	PS-19-14: Complete the Double Asteroid Redirection Test (DART) Critical Design Review (CDR).

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.

2017 Performance Results
Green

The Earth Science Advisory Committee (ESAC) determined in October 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. NASA's Atmospheric Composition focus area continues to provide quantitative global observations from space, augmented by suborbital and ground-based measurements of atmospheric aerosols and greenhouse and reactive gases, enabling the scientific community to improve understanding of their impacts on climate and air quality. Selected research results from FY 2017 are highlighted below.

Atmospheric aerosols like black carbon, a component of soot, and brown carbon, from smoldering fires and similar combustion, absorb light and warm the atmosphere. The effects of black carbon on the atmosphere are well known, but recent research has provided more insight into the role brown carbon plays in climate forcing. A recent study, which used aircraft observations from NASA's Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS) campaign, showed that brown carbon is prevalent in the troposphere. The troposphere is the lowest layer of Earth's atmosphere. The brown carbon absorbs more short-wavelength radiation than black carbon at altitudes between 5 and 12 kilometers. The observations showed that brown carbon is transported to these altitudes by deep convection, and suggested that brown carbon accounts for about 24 percent of the combined black and brown carbon warming effect at the tropopause, or the boundary between the troposphere and the stratosphere. The study concluded that high-altitude brown carbon from biomass burning is an underappreciated component of climate forcing.

Nature published an article showing that drylands are affected to a greater degree by climate change than other climate zones, with an increase of mean surface temperature of more than 40 percent above the global warming limit of two degrees Celsius set by the Paris Agreement. The researchers used Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol and cloud observations, as well as other data, as inputs to climate model simulations to estimate these radiative effects.

With the ongoing debate about closing coal-fired power plants across the United States, there is interest in the potential impact on regional atmospheric particulate matter with a diameter of less than 2.5 micrometers ($PM_{2.5}$). A study explored the impacts of closing three coal-fired power plants in southwestern Pennsylvania on regional air quality from January 2011 through December 2014. Scientists used observations from MODIS and the Environmental Protection Agency's $PM_{2.5}$ ground stations in order to check the performance of a series of models. The study concluded that the models were correctly predicting the downward trend in aerosol loading (suspensions of solids and/or liquid particles in the air that humans breathe) following each power plant shutdown.

A new statistical model suggests that climate change will amplify dust activity in parts of the United States in the latter half of the 21st century, which may lead to an increased frequency of large dust storms that have far-reaching impacts on public health and infrastructure. This model eliminates some of the uncertainty found in previous dust activity models by using present-day satellite data, such as dust optical depth, leafy green coverage over land, and other factors.

Ozone is an important air pollutant at the surface, and the third most important anthropogenic greenhouse gas in the troposphere. A *Nature* publication suggests that increasing emissions in Southeast, East, and South Asia may be the largest drivers of ozone change. Data suggest that the future ozone burden will be determined mainly by emissions from low latitudes.

Formaldehyde is a dominant carcinogen in outdoor air and a precursor for tropospheric ozone. A study used satellite data, validated with aircraft in-situ data, and the Goddard Earth Observing System (GEOS)-Chem chemical transport model to map surface air formaldehyde concentrations across the contiguous United States. Based on this dataset, scientists estimate that up to 6,600 to 12,500 people in the United States will develop cancer over their lifetimes due to exposure to outdoor formaldehyde. Further, they find that formaldehyde levels would decrease by 20 to 30 percent in the absence of U.S. anthropogenic nitrogen oxide emissions. Thus, nitrogen oxide emission controls to improve ozone air quality have a significant co-benefit in reducing formaldehyde-related cancer risks.

Performance Goal 1.1.17 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.17)

Year	Description
2018	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.
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.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.17 Annual Performance Indicators

Annual Performance Indicator 1.1.17: ES-17-1

Year	Description
Rating	**Green**
2017	ES-17-1: 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.
2018	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.
2019	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.

Performance Goal 1.1.18

Demonstrate progress in improving the capability to predict weather and extreme weather events.

2017 Performance Results
Green

The Earth Science Advisory Committee (ESAC) determined in October 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. Most of the research and development supporting this performance goal continues to be in precipitation science, though the focus is evolving to include other new topics. Over the past year, NASA conducted successful field campaigns to advance understanding of weather-producing processes, and continued to study the behavior of weather systems using integrated modeling and data assimilation systems. Below are examples of the scientific progress reported in FY 2017.

An analysis of Global Precipitation Measurement (GPM) mission data shows an improved representation of monsoon precipitation and its interaction with atmospheric dynamics over West Africa. Short-term forecasts of soil moisture and other parameters to better understand the land-atmosphere interactions on scales of days to years have been developed based on GPM data, along with other precipitation data, and are available from the NASA Land Information System (LIS). Routine LIS data assimilation studies performed at NASA's Short-term Prediction Research and Transition (SPoRT) Center have shown that increased land surface model grid resolution (down to approximately three kilometers) can yield an improvement in the estimation of the surface water balance. GPM's data for extreme precipitation leading to flood or landside events, and the characterization of potential hazards, are a source of several GPM investigations. For example, a study used GPM data to monitor and characterize heavy precipitation events that occurred during the 2014 fall season in Italy. The results showed that GPM provides a reliable and quantitative description of the precipitation (instantaneous and on the daily scale) throughout the evolution of the precipitation systems in the Mediterranean region. The comparable relative errors among gauges, radar, and combinations of satellite overpasses demonstrated the use of GPM as a valuable and independent tool for monitoring precipitation. This is particularly relevant in the presence of complex orography in the proximity of coastal areas, as for the analyzed cases.

The Convective Process Experiment (CPEX) was competitively selected as part of the Research Opportunities in Space and Earth Science (ROSES) 2016 solicitation to help answer questions about convective storm initiation, organization, and growth. CPEX took place in the North Atlantic-Gulf of Mexico-Caribbean Sea region from May 25 to June 25, 2017, onboard NASA's DC-8 aircraft, based out of Fort Lauderdale, FL. During CPEX, the science team logged 106 flight hours and a total of 16 science missions (91 hours) that covered a wide range of weather conditions from clear and calm wind, isolated convective cloud systems, to Tropical Storm Cindy, which formed in the Gulf of Mexico prior to landfall in Louisiana on June 22, 2017. CPEX was the first field campaign to collect airborne observations continually from pre-tropical disturbance in the Caribbean Sea, to tropical depression, and subsequent formation of a tropical storm.

The SPoRT Center continued to facilitate the transition of unique observations and research capabilities to the operational weather community to improve short-term forecasting. SPoRT has contributed to the transition of Geostationary Lightning Mapper (GLM) and Advanced Baseline Imager (ABI) observations from the new Geostationary Operational Environmental Satellite (GOES)-16 weather satellite to operational forecasters at the National Weather Service. As part of this effort, the project has developed training for specific GLM products, addressing their strengths and weaknesses, with the goal of successfully transitioning products to operations. SPoRT has completed integration of retrieved soil moisture observations from the NASA Soil Moisture Active Passive (SMAP) mission into an offline version of the LIS, and is currently tuning the model to improve impacts and planning its transition to operational systems.

Performance Goal 1.1.18 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.18)

Year	Description
2018	1.1.18: Demonstrate progress in improving the capability to predict weather and extreme weather events.
2019	1.1.18: Demonstrate progress in improving the capability to predict weather and extreme weather events.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.18 Annual Performance Indicators

Annual Performance Indicator 1.1.18: ES-17-2

Year	Description
Rating	Green
2017	ES-17-2: Demonstrate planned progress in improving the capability to predict weather and extreme weather events.
2018	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.
2019	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.

Annual Performance Indicator 1.1.18: ES-17-6

Year	Description
Rating	**Green**
2017	ES-17-6: Achieve the Cyclone Global Navigation Satellite System (CYGNSS) mission success criteria.
2018	No API this fiscal year.
2019	No API this fiscal year.

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.

2017 Performance Results
Green

The Earth Science Advisory Committee (ESAC) determined in October 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. NASA research in the Carbon Cycle and Ecosystems focus area continues to increase knowledge of changes in Earth's biogeochemical cycles, ecosystems, land cover, and biodiversity, balancing between global and regional studies, with local studies providing insight into important processes that elucidate each region's unique role in the Earth system. Selected highlights from FY 2017 are summarized below.

Research by the Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign has documented the extent of permafrost thaw in Alaska and Canada. These studies have also provided an improved understanding of the seasonal dynamics of emissions of carbon dioxide and methane from tundra, where significant autumn and winter emissions have been documented. These emissions have increased 73 percent (±11 percent) since 1975 and are correlated with increasing summer temperature.

Scientists used spaceborne light detection and ranging (lidar) data to study variations in the canopy and understory structure in Amazon tropical forests in order to understand factors influencing light-driven growth during the dry season. The data showed that both the understory and canopy were responding to variations in light conditions, as well as consecutive and cumulative dry and wet regimes.

At the global scale, modeling studies showed that during the recent warming period from 1980-1992, increased net biome productivity—the net gain or loss of carbon from an ecosystem—was not due to increased primary production, where plants use photosynthesis to turn inorganic material into energy-rich organic material. Instead, it was due to decreased heterotrophic respiration, which is the metabolism of organic material by animals, bacteria, and fungi. The modeling studies also showed that at both local and regional scales, water availability is a strong regulator of both gross primary productivity and terrestrial ecosystem respiration.

In September 2017, scientists published a special collection of five papers summarizing study results from the Orbiting Carbon Observatory (OCO)-2 in the journal *Science*. OCO-2 has collected almost one million soundings globally each day since September 2014. In one study, data from OCO-2 and the Mauna Loa Observatory in Hawaii show that the 2015-2016 El Niño event coincides with the largest annual increase in carbon dioxide since measurements began in the 1950s, even though human emissions were roughly the same as in the preceding year. Another study using OCO-2 data showed that tropical continents were the primary source of that record increase of carbon dioxide, with about 2.5 gigatons higher carbon emissions as compared to 2011, which is considered a normal year for carbon emissions. In the 2015-2016 El Niño period, tropical South America, including the Amazon rainforest, was the driest it has been in the last 30 years. Trees went dormant or died, reducing photosynthesis and leaving more carbon in the atmosphere. African rainforests endured hotter than normal temperatures. Decomposition of dead trees increased, releasing more carbon into the atmosphere. In Southeast Asia, drought increased the size and duration of peat and forest fires, also releasing more carbon into the atmosphere.

Satellite remote sensing data collected over the past two decades have been used in combination with longer-term fire management records to study changes in the extent of area burned during human-caused and lightning-ignited fires. While human activities related to the intensification of agriculture have resulted in a decrease in burned area globally over the last 18 years, an increase in human ignitions and a warming climate are key contributors to increased wildfire area burned in the western United States. In the western boreal forest region of North America, increased wildfire activity has been linked to increases in lightning ignitions, as well as warming conditions and extended fire seasons.

Studies focused on the feedbacks between urban land cover and urban climate have shown that the urban heat island effect can impact both surface temperature and vegetation life cycles as far away as 15 kilometers from an urban core.

Performance Goal 1.1.19 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.19)

Year	Description
2018	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.
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.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.19 Annual Performance Indicators

Annual Performance Indicator 1.1.19: ES-17-3

Year	Description
Rating	Green
2017	ES-17-3: Demonstrate planned progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.
2018	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.
2019	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.

Annual Performance Indicator 1.1.19: ES-17-12

Year	Description
Rating	**Green**
2017	ES-17-12: Achieve the Orbiting Carbon Observatory (OCO)-2 mission success criteria.
2018	No API this fiscal year.
2019	No API this fiscal year.

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.

2017 Performance Results
Green

The Earth Science Advisory Committee (ESAC) determined in October 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. NASA's Water and Energy Cycle focus area continues to develop tools that contribute to a better evaluation of the global water cycle budget and improved assessment of water quality, enabling improved water resource management. Selected highlights from FY 2017 are briefly described below.

Global precipitation variations over the satellite era were reviewed in a recent publication using monthly datasets from the Global Precipitation Climatology Project. The satellite era has seen small increases in global precipitation variations during El Niños, and noticeable decreases after major volcanic eruptions. While the research showed no overall significant trend in the global precipitation mean, scientists did find that there is a pattern of increased rainfall over tropical oceans and decreased rainfall over some middle latitude regions. These observed patterns result from a combination of inter-decadal variations and global warming during the study period (1979-2014).

Atmospheric rivers are relatively long, narrow, short-lived jets of air that transport water vapor across significant portions of Earth's mid-latitude oceans, onto the continents and into Earth's polar regions. A recent study published in *Nature Geosciences* found that atmospheric rivers comprise half of the top two percent of the most extreme precipitation and wind events across most mid-latitude regions globally. Atmospheric rivers that make landfall are associated with about 40 to 75 percent of extreme wind and precipitation events over 40 percent of the world's coastlines. Atmospheric rivers are also associated with a doubling (or more) of the typical wind speed and precipitation amounts compared to all storm conditions, and with a 50 to 100 percent increase in the probability for an extreme event. The majority of extreme wind events over Europe catalogued between 1979 and 2013, with losses in excess of the equivalent of $1 billion each, were associated with atmospheric rivers.

Although the Soil Moisture Active Passive (SMAP) mission was primarily designed to measure and quantify soil moisture over the continents, a new investigation showed that SMAP data can also be used to monitor ocean winds. The near-surface ocean wind is a driving force in air-sea interaction process and is a key component in forecasts of tropical cyclone track and intensity, requiring accurate direct observations of the surface wind field. However, traditional spaceborne radiometers and scatterometers, operating at C- to Ka-band frequencies, have limited sensitivity to strong, hurricane-force winds. The study demonstrated the advantage of using L-band microwave wind radiometers from SMAP in filling a critical gap for surface observations during severe weather. A related study found that the performance of SMAP wind vectors is superior to traditional scatterometers for high-wind conditions (greater than 12.5 meters per second), opening new frontiers in marine hazard avoidance.

A recent study combined soil moisture information from SMAP with data on terrestrial water storage (a measure of all forms of water on or below Earth's surface, including surface water, soil moisture, groundwater, snow, and ice), enhanced vegetation index (a measure of vegetation that controls for the plant canopy and atmospheric influences), and solar-induced fluorescence (a plant process that occurs during photosynthesis) to investigate multiple aspects of the water cycle, as well as its interaction with the carbon cycle. Researchers found that the amount of moisture in vegetation is highly correlated with mean annual precipitation. Although grassland is susceptible to drought, it tends to recover quickly. Generally, near surface soil moisture is coupled with, and has similar characteristic time scales to, terrestrial water storage.

Scientists used data from NASA's Gravity Recovery and Climate Experiment (GRACE) to develop a drought severity index, known as GRACE-DSI, that monitors terrestrial water storage changes. This index has closely tracked existing monthly indices, such as the Palmer Drought Severity Index, as well as surface soil moisture estimates and in-situ groundwater observations. GRACE data and GRACE-DSI also incorporate the human impacts of groundwater withdrawal.

Performance Goal 1.1.20 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.20)

Year	Description
2018	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.
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.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.20 Annual Performance Indicators

Annual Performance Indicator 1.1.20: ES-17-4

Year	Description
Rating	**Green**
2017	ES-17-4: 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.
2018	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.
2019	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.

Annual Performance Indicator 1.1.20: ES-17-17

Year	Description
Rating	**Green**
2017	ES-17-17: Achieve the Global Precipitation Measurement (GPM) mission success criteria.
2018	No API this fiscal year.
2019	No API this fiscal year.

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.

2017 Performance Results
Green

The Earth Science Advisory Committee (ESAC) determined in October 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. The NASA Climate Variability and Change focus area supports a wide range of interdisciplinary research, leading efforts to collect and interpret data acquired from satellite, aircraft, and ground-based observations of sea ice, glaciers, ice sheets, and the global ocean, and to integrate these data into comprehensive, interactive Earth system models. Selected highlights from FY 2017 are summarized below.

Research in the processes that govern seasonal and long-term sea ice revealed that the rapid loss of Arctic sea ice continued this past year, reaching its minimum extent for 2016 on September 10, at 4.14 million square kilometers (1.60 million square miles). This ties with the 2007 minimum as the second-lowest extent in the passive-microwave satellite record, and reinforces the long-term downward trend in Arctic ice extent (a 13.3 percent decrease per decade). The 10 lowest September sea ice extents in the satellite record have all occurred in the last 10 years.

After four years of record or near-record maximum extents, sea ice around Antarctica plummeted to its lowest minimum extent in the satellite record on March 3, 2017, at 2.11 million square kilometers (815 thousand square miles). This reflected especially low sea ice extent along the coast of West Antarctica, particularly in the Amundsen and Ross Seas. The previous record-low minimum extent occurred in February 1997.

Scientists found a connection between the frequency of El Niño events and the influence of El Niño on global mean surface temperatures. They suggest that El Niño-Southern Oscillation (ENSO) events control year-to-year variations in the atmospheric healing rate in the tropics, emphasizing the importance of ocean heat uptake for interpreting global temperature curves. Their analysis explains, for example, the continuing global warming trend and rapid temperature rise that accompanied ENSO conditions during 2014 to 2016. Alternatively, weak ENSO activity can lead to slower rates of increase in global surface temperatures, such as those observed in the mid-2000s, dubbed the “global warming hiatus.”

A recent study quantified the exchange of water between land and ocean, through precipitation, evaporation, and winds, and its impact on sea levels. Using Gravity Recovery and Climate Experiment (GRACE) measurements, the team estimated that as a result of climate changes, an additional 3,200 gigatons of water has been stored on land since 2002. This net groundwater storage partially offsets water losses from melting ice sheets, glaciers, and groundwater extraction, thus slowing down the rate of recent sea level rise by about 15 percent.

With rising seas, coastal flooding can increase even at fairly normal high tides, with no additional contribution from storms, winds, or rain. These tidal flooding events are “nuisance” floods, which can affect a large population in low-lying coastal regions. Analysis of satellite altimeter data and tide-gauge records by NASA scientists suggests that the nuisance flooding has markedly increased in recent years along the East Coast of the United States. Using different scenarios of future sea level rise, they predict further increase in the frequency and magnitude of tidal flooding events in the Boston area between now and 2050.

Several studies investigate the predictability of weather forecasts on subseasonal time scales. They find that an operational forecast model can accurately predict averages of temperature and precipitation over the contiguous United States out to about three to four weeks. The most predictable components of winter

temperature and precipitation are related to ENSO. These results establish a scientific basis for improving weather and climate predictions for three to four weeks in the future.

Performance Goal 1.1.21 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.21)

Year	Description
2018	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.
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.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.21 Annual Performance Indicators

Annual Performance Indicator 1.1.21: ES-17-5

Year	Description
Rating	Green
2017	ES-17-5: Produce three consistent indicators of critical Earth system parameters based on data from NASA research satellites (either on their own or in conjunction with non-NASA satellites) to help document long-term Earth system evolution. Indicators will cover time scales appropriate for climate variability and change studies.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 1.1.21: ES-17-7

Year	Description
Rating	**Green**
2017	ES-17-7: 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.
2018	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.
2019	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.

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.

2017 Performance Results
Green

The Earth Science Advisory Committee (ESAC) determined in October 2017 that NASA remained on track in its annual performance towards the achievement of this performance goal. NASA's Earth Surface and Interior focus area continues to advance the understanding of core, mantle, and lithospheric structure and dynamics, and interactions between these processes and Earth's fluid envelopes, needed to inform the assessment and mitigation of natural hazards. Below are examples of the scientific progress reported in FY 2017.

Using data from the Japanese tsunami on March 11, 2011, a study team assessed two independent approaches for determining tsunami source energy, including one that inverted Deep-ocean Assessment and Reporting of Tsunamis (DART) data during the tsunami propagation, and another that derived from the land-based coastal Global Positioning System (GPS) during tsunami generation. While the GPS approach takes into consideration the dynamic earthquake process, the DART inversion approach provides the actual tsunami energy estimation of the propagating tsunami waves. Both approaches lead to consistent energy scales for previously-studied tsunamis. The team developed a real-time approach that combines the two methods: first, determine the tsunami source from the global GPS network immediately after an earthquake for near-field early warnings, and then refine the tsunami energy estimate from nearby DART measurements for improving forecast accuracy. This methodology has been integrated into the National Oceanic and Atmospheric Administration's (NOAA's) early warning system.

NASA's Space Geodesy Program (SGP) completed the commissioning of the joint NASA-United States Naval Observatory broadband very-long-baseline interferometry (VLBI) Global Observing System (VGOS) station at NASA's Kōke'e Park Geophysical Observatory (KPGO) in Hawaii. The station is now operational. In May 2017, a 24-hour VGOS test session was successfully performed using the new KPGO station, along with the Haystack Observatory in Westford, Massachusetts; Goddard Geophysical and Astronomical Observatory (GGAO) in Maryland; Geodetic Observatory Wettzell in Germany; and Yebes Observatory in Spain. This session provided the first-ever combined transpacific, transarctic, and transatlantic VGOS measurements.

The SGP also worked with the Norwegian Mapping Authority on an agreement for the development and implementation of a NASA Satellite Laser Ranging (SLR) station in Ny-Ålesund, Norway, a unique location within the Arctic Circle that will be particularly valuable in supporting the tracking of NASA's polar orbiting satellites. The agreement was signed during an August 2017 visit of the Norwegian delegation to NASA Headquarters.

A *Science* article by a research team of 29 co-authors from 11 National and international institutes described the process of combining satellite radar interferometry and GPS data to understand the intricacies of the 7.8 (on the moment magnitude scale) Kaikoura earthquake in New Zealand. The team found that the 2016 earthquake, during which parts of New Zealand's South Island moved more than five meters closer to New Zealand's North Island and were uplifted by as much as eight meters, was likely the most complex earthquake in modern history. The quake ruptured at least 12 major crustal faults, with evidence of slip along the southern end of the Hikurangi subduction zone plate boundary. These results will improve seismic hazard models.

Performance Goal 1.1.22 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.22)

Year	Description
2018	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.
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.

Data Quality Elements

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 annual performance indicator that supports this performance goal. 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's Science Mission Directorate (SMD), with any issues being resolved by the Associate Administrator for SMD.

Verification and 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 Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.22 Annual Performance Indicators

Annual Performance Indicator 1.1.22: ES-17-8

Year	Description
Rating	**Green**
2017	ES-17-8: 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.
2018	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.
2019	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.

Performance Goal 1.1.23

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

2017 Performance Results
Green

NASA's Applied Sciences Program enables innovative and practical uses of Earth observations by businesses, governments, and nonprofits to inform their decisions and actions. The enhanced decision-making made possible by the program's projects improves quality of life and strengthens the economy. Following are some recent examples:

- The National Weather Service used vegetation indices obtained by NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS), Landsat multispectral composites, and other Earth observations to enhance its Storm Damage Assessment Toolkit. The additional Earth observations will help refine tornado, severe thunderstorm, and other damage surveys used by downstream partners and scientists.
- The South Dakota Department of Health used information products about West Nile Virus based on MODIS, Landsat, and the North American Land Data Assimilation System (NLDAS) to help establish priorities for mosquito control and disease prevention.
- The U.S. Environmental Protection Agency used nitrogen dioxide data from Aura's Ozone Monitoring Instrument (OMI) in its AirTrends Report 2016. This marked the first time that the report included satellite data.
- Using information derived from MODIS sea ice data and Landsat imagery, the Association of Responsible Krill harvesting companies were able to identify the location of penguin colonies in the Antarctic and agreed to voluntarily refrain from fishing near them, supporting a sustainable fishery and long-term operations.
- The United Nations Great Apes Survival Partnership expanded its use of a SERVIR-developed database of the world's tropical rainforest biomass, helping guide rainforest preservation and great ape conservation in Africa.
- The Nature Conservancy and the Maricopa County Department of Public Health used Aqua land-surface temperature, Aqua emissivity data, and Landsat imagery to identify populations most vulnerable to extreme heat and guide service efforts.

In addition, NASA used the vantage point of space to support the response to 106 National and international disasters. For example:

- NASA supported the response to Hurricanes Matthew, Harvey, Irma, and Maria. Information products derived from the Suomi National Polar-orbiting Partnership (Suomi NPP), MODIS, Soil Moisture Active Passive (SMAP), Global Precipitation Measurement (GPM), Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR), Advanced Land Observing Satellite 2 (ALOS-2), COnstellation of small Satellites for the Mediterranean basin Observation (COSMO-SkyMed), Copernicus Sentinel satellites, and other sources assisted the National Guard, Federal Emergency Management Agency (FEMA), state officials, and others in disaster response efforts, such as characterization of flood extent, saturated soils prone to flooding, power outages, and impacts to areas of critical infrastructure.
- NASA supported responses to the Chiapas and Raboso earthquakes in Mexico, providing landslide susceptibility maps and synthetic aperture radar (SAR) damage proxy maps.
- NASA supported the response to extreme rainfall and flooding in Nepal, providing flood inundation area products based on Copernicus-Sentinel-1 data from the European Space Agency (ESA) to support prioritization of relief areas.

The Earth science applications project teams achieved higher Application Readiness Levels (ARLs) with their projects, indicating that project teams are advancing the transfer and adoption of use of the observations into the decision-making processes of the user organizations. Of the 93 projects tracked, the Applied Sciences Program advanced 54 projects, or 58 percent, at least one ARL. NASA uses this index to track the maturity level of projects, from basic research through development, transition, and operational deployment.

The DEVELOP program, an endeavor for young professionals to work with user organizations to apply Earth science data, included 352 participants in 73 projects. Their work involved 135 unique partner organizations and served efforts in 38 U.S. states. The Applied Sciences training endeavor on remote sensing for professionals conducted 18 virtual and in-person trainings, including a first-ever training on SAR that had record attendance. The trainings reached over 4,800 people, with participants in all 50 U.S. states, over 125 countries, and hundreds of private sector organizations. The SERVIR program (managed jointly with the U.S. Agency for International Development) launched a Service Planning Toolkit to support user engagement in Earth observations tool development and to increase tool sustainability.

Sponsored by Applied Sciences, a multi-disciplinary organizational consortium led by Resources for the Future began work to develop analytic methods for quantifying the socioeconomic benefits from uses of Earth observations. In addition, a consortium led by the University of Maryland began efforts to advance uses of Earth observations by domestic and international organizations to improve food security and agriculture decisions. Applied Sciences managed the 2017 International Space Apps Challenge, which focused on Earth themes and involved a record 25,000 participants across 69 countries.

The Applied Sciences Program also engaged the applications community to expand knowledge about NASA's Earth science missions and in planning for upcoming satellites. The Surface Water Ocean Topography (SWOT) and NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) missions held applications workshops; Ice, Cloud, and land Elevation Satellite (ICESat)-2 conducted a focus session on sea level and continued with participants in the ICESat-2 Early Adopter program to apply the data and information; NISAR developed 16 examples of potential applications, and Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) created a series of applications concepts; SWOT and ICESat-2 engaged users at an American Water Resources Association symposium; GPM held an agricultural applications workshop; and Gravity Recovery and Climate Experiment (GRACE) created a user guideline to make GRACE data applications easier.

Performance Goal 1.1.23 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.1.23)

Year	Description
2018	1.1.23: Further the use of Earth system science research to inform decisions and provide benefits to society.
2019	1.1.23: Further the use of Earth system science research to inform decisions and provide benefits to society.

Data Quality Elements

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 and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.23 Annual Performance Indicators

Annual Performance Indicator 1.1.23: ES-17-9

Year	Description
Rating	**Green**
2017	ES-17-9: Advance at least 40 percent of Earth science applications projects one Applications Readiness Level.
2018	ES-18-7: Advance at least 40 percent of Earth science applications projects one Applications Readiness Level.
2019	ES-19-7: Advance at least 40 percent of Earth science applications projects one Applications Readiness Level.

Annual Performance Indicator 1.1.23: ES-17-10

Year	Description
Rating	**Green**
2017	ES-17-10: Maintain high level of customer satisfaction, as measured by exceeding the most recently available Federal Government average rating of the American Customer Satisfaction Index.
2018	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.
2019	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.

Performance Goal 1.1.24

By December 2017, launch at least five missions in support of Earth Science.

2017 Performance Results
Yellow

Through FY 2017, NASA launched four major missions in support of this performance goal, including the joint NASA-Japan Aerospace Exploration Agency (JAXA) Global Precipitation Measurement (GPM) mission in February 2014, Orbiting Carbon Observatory (OCO)-2 in July 2014, Soil Moisture Active Passive (SMAP) mission in January 2015, and Cyclone Global Navigation Satellite System (CYGNSS) mission in December 2016.

NASA had planned to complete this goal with the launch of the Gravity Recovery and Climate Experiment-Follow On (GRACE-FO) mission, for which launch services are being contributed by the German Research Centre for Geosciences (GFZ), NASA's international partner for the mission. Originally, GFZ contracted with International Space Company (ISC) Kosmotras to provide a Dnepr launch vehicle; however, the Russian government suspended launches of the Russian-Ukrainian Dnepr rocket. Subsequently, GFZ entered into a Ride-Share Agreement with Iridium Communications, Inc. to provide launch services with five Iridium NEXT satellites on a commercially-procured Falcon 9 launch vehicle from Vandenberg Air Force Base, CA.

Performance Improvement Plan

GFZ and Iridium have formally agreed to a 30-day launch window beginning March 17, 2018, with a target launch readiness date (LRD) of March 21, 2018.

Performance Goal 1.1.24 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Yellow	Yellow

Planned Future Performance (PG 1.1.24)

Year	Description
2018	1.1.24: By December 2021, launch three missions in support of Earth Science.
2019	1.1.24: By December 2021, launch three missions in support of Earth Science.

Data Quality Elements

Data Source
Written explanation of the rating and supporting material from the Science Mission Directorate's (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 and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.24 Annual Performance Indicators

Annual Performance Indicator 1.1.24: ES-17-11

Year	Description
Rating	**Green**
2017	ES-17-11: Launch Cyclone Global Navigation Satellite System (CYGNSS).
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 1.1.24: ES-17-13

Year	Description
Rating	**Yellow**
2017	ES-17-13: Complete Ice, Cloud, and Land Elevation Satellite (ICESat)-2 Pre-Ship Review (PSR).
2018	ES-18-13: Launch the Ice, Cloud, and Land Elevation Satellite (ICESat)-2.
2019	No API this fiscal year.

Explanation of Rating

NASA delayed the Ice, Cloud, and Land Elevation Satellite (ICESat)-2 Pre-Ship Review (PSR) to June 2018. During thermal-vacuum testing in July 2016, one of the two onboard flight lasers experienced an anomaly when powered-on at a cold qualification temperature. The anomaly was caused by the laser's pre-amplifier crystal slab, which had fractured towards the center. The ensuing failure investigation and redesign and rebuilds of the pre-amplifier and amplifiers for both flight lasers delayed completion of the Advance Topographic Laser Altimeter System (ATLAS) instrument.

NASA established an ICESat-2 launch readiness date of September 2018.

Annual Performance Indicator 1.1.24: ES-17-14

Year	Description
Rating	**Green**
2017	ES-17-14: Complete the Surface Water and Ocean Topography (SWOT) Ka-band Radar Interferometer (KaRIN) instrument Critical Design Review (CDR).
2018	ES-18-11: Complete the Surface Water and Ocean Topography (SWOT) mission Critical Design Review (CDR).
2019	ES-19-9: Complete Surface Water and Ocean Topography (SWOT) System Integration Review (SIR).

Annual Performance Indicator 1.1.24: ES-17-15

Year	Description
Rating	**Yellow**
2017	ES-17-15: Complete the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission Pre-Ship Review (PSR).
2018	ES-18-12: Launch the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) mission.
2019	No API this fiscal year.

Explanation of Rating

The GRACE-FO Pre-Ship Review (PSR) was not completed until November 2017, consistent with the expected launch in March 2018. As noted previously, launch services for GRACE-FO are being contributed by GFZ, NASA's international partner for the mission. Originally, GFZ contracted with ISC Kosmotras to provide a Dnepr launch vehicle; however, the Russian government suspended launches of the Russian-Ukrainian Dnepr rocket. Subsequently, GFZ entered into a Ride-Share Agreement with Iridium Communications, Inc. to provide launch services with five Iridium NEXT satellites on a commercially-procured Falcon 9 launch vehicle from Vandenberg Air Force Base, CA.

GFZ and Iridium have formally agreed to a 30-day launch window beginning March 17, 2018, with a target LRD of March 21, 2018.

Annual Performance Indicator 1.1.24: ES-17-16

Year	Description
Rating	**Yellow**
2017	ES-17-16: Complete NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) Antenna-Reflector Critical Design Review (CDR).
2018	ES-18-10: Complete NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) L-Band SAR Instrument Critical Design Review (CDR).
2019	ES-19-10: Complete NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) Critical Design Review (CDR).

Explanation of Rating

The NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR) Radar Antenna Reflector Critical Design Review (CDR) was not completed until October 2017 to allow for the accommodation of increased loads and for the redesign of the launch restraint release mechanism to reduce the shock level for the environmental testing and the launch itself.

The impact of the delay on the overall project schedule is minor, since the Radar Antenna Reflector is not on the project critical path and the project is carrying approximately 200 working days of schedule margin.

Annual Performance Indicator 1.1.24: ES-17-18

Year	Description
Rating	**Yellow**
2017	ES-17-18: Complete the Earth Venture Instrument (EVI)-4 selection.
2018	ES-18-14: Release the Earth Venture Instrument (EVI)-5 Announcement of Opportunity.
2019	ES-19-11: Complete Earth Venture Instrument (EVI)-5 evaluation panel.

Explanation of Rating

The Earth Venture Instrument (EVI)-4 selection was delayed to CY 2018 due to a procurement-related procedural issue.

Annual Performance Indicator 1.1.24: ES-17-19

Year	Description
Rating	**Green**
2017	ES-17-19: Complete the Landsat 9 Thermal Infrared Sensor (TIRS)-2 instrument Critical Design Review.
2018	ES-18-9: Complete the Landsat 9 Critical Design Review (CDR).
2019	ES-19-12: Complete Landsat 9 Thermal Infrared Sensor (TIRS)-2 instrument Pre-Ship Review (PSR).

Annual Performance Indicator 1.1.24: ES-18-15

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	ES-18-15: Complete the Earth Venture Suborbital (EVS)-3 selection.
2019	No API this fiscal year.

Annual Performance Indicator 1.1.24: ES-19-13

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	ES-19-13: Complete Sentinel-6 Pre-Ship Review (PSR)-A.

Strategic Objective 1.2

Understand the responses of physical and biological systems to spaceflight.

Lead Office:
Human Exploration and Operations Mission Directorate (HEOMD)

Contributing Programs/Projects:
International Space Station (ISS) Research

Goal Leader:
Mark Geyer, Acting Deputy Associate Administrator, Technical, HEOMD

Objective Overview

NASA will lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations. NASA is now developing unique new deep-space systems that includes the Orion crew capsule, the Space Launch System (SLS) very heavy-lift launch vehicle, and supporting ground facilities. Precursor robotic missions that investigate candidate destinations and provide vital information for human explorers will lay the groundwork for deep-space exploration.

Sending astronauts into space involves a multitude of complicated systems, but perhaps the most complex is the human system. As NASA prepares to conduct crewed missions in cis-lunar space, and eventually at other locations including Mars, the Human Research Program biomedical research and technological development are enabling the Agency to safely send humans into deep space for these longer durations. The capability to transport humans to and from deep space will lead to creation of a permanent, long-term human space presence in the solar system. While new knowledge increases understanding of Earth, the solar system, the universe, and ourselves, Americans expect tangible benefits and applications that can be used on Earth. If the past is prologue, scientists and entrepreneurs will generate new uses for the knowledge and technology resulting from NASA’s investments in exploration systems, and this in turn will grow the U.S. economy.

Strategic Objective 1.2 Data Summary

Performance Goal Ratings (1.2.1 - 1.2.1)

Fiscal Year	Total	Green	Yellow	Red	White
2017	1	0	1	0	0
2016	1	0	0	1	0
2015	1	0	1	0	0
2014	1	1	0	0	0
2013	1	1	0	0	0
2012	1	1	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	4	3	0	1	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 1.2.1

Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise.

2017 Performance Results
Yellow

During FY 2017, NASA made significant progress toward this performance goal, demonstrating its focus on conducting basic and applied scientific research aboard the International Space Station (ISS). Following are a few of the major accomplishments in biological and physical research that NASA completed in FY 2017:

- NASA completed flight projects on combustion and fluids research on the ISS, including both Spacecraft Fire Experiment (Saffire)-II and Saffire-III. The series of combustion experiments was designed to investigate large-scale flame growth and material flammability limits in space, in order to help inform operational protocols for dealing with fire emergencies, particularly when astronauts do not have the ability to exit a spacecraft or quickly return to Earth.
- NASA has 21 funded projects designed to address the critical questions on microbial life in space identified by the National Academies in its 2011 decadal survey, *Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era*. This research is probing the underlying mechanisms behind the adaptations of microbes, plants, and animals to spaceflight, which will help scientists understand the ways in which biological systems use gravity to regulate and sustain their growth, metabolism, reproduction, and development, as well as how they repair damage and protect themselves from infection and disease.
- The Center for the Advancement of Science in Space (CASIS) released four solicitations, intended to expand the use of the ISS by public and private organizations other than NASA. Evaluations and research projects have been selected and flown to the ISS on Commercial Resupply Services missions.

NASA did not complete one of its planned objectives for FY 2017. Specifically, the delivery of the Cold Atom Laboratory to the ISS shifted to late in the first quarter of FY 2018. The Cold Atom Laboratory will be a facility aboard the ISS for the study of ultra-cold quantum gases in microgravity, enabling research in an environment that is inaccessible to Earth-based laboratories.

Performance Improvement Plan

As noted above, NASA rescheduled the launch of the Cold Atom Laboratory to the ISS to early FY 2018. After delivery, the ISS will complete installation, power-up, and checkout of the facility.

Performance Goal 1.2.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Yellow	Red	Yellow

Planned Future Performance (PG 1.2.1)

Year	Description
2018	1.2.1: Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise.
2019	1.2.1: Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise.

Data Quality Elements

Data Source
Documentation for payloads delivered to the ISS Program; ISS flight manifests; Standing Review Board (SRB) program reports; CASIS press releases and award documents; and the NASA Task Book bibliographic data.

Verification and Validation
Review of the documentation listed under Data Sources.

Data Limitations
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.

Performance Goal 1.2.1 Annual Performance Indicators

Annual Performance Indicator 1.2.1: ISS-17-10

Year	Description
Rating	**Green**
2017	ISS-17-10: Produce at least 13 peer-reviewed publications addressing the critical questions on microbial life in space identified by the National Research Council in the Decadal Survey for Life and Physical Sciences in Space.
2018	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.
2019	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.

Annual Performance Indicator 1.2.1: ISS-17-5

Year	Description
Rating	**Red**
2017	ISS-17-5: Deliver the Cold Atom Laboratory facility to the International Space Station and initiate operations on orbit, and complete one flight project in combustion research and one flight project in fluid physics or complex fluids research.
2018	ERD-18-4: 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.
2019	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.

Explanation of Rating

See above. Following delivery, the ISS will complete installation, power-up, and checkout of the Cold Atom Laboratory facility.

Annual Performance Indicator 1.2.1: ISS-17-6

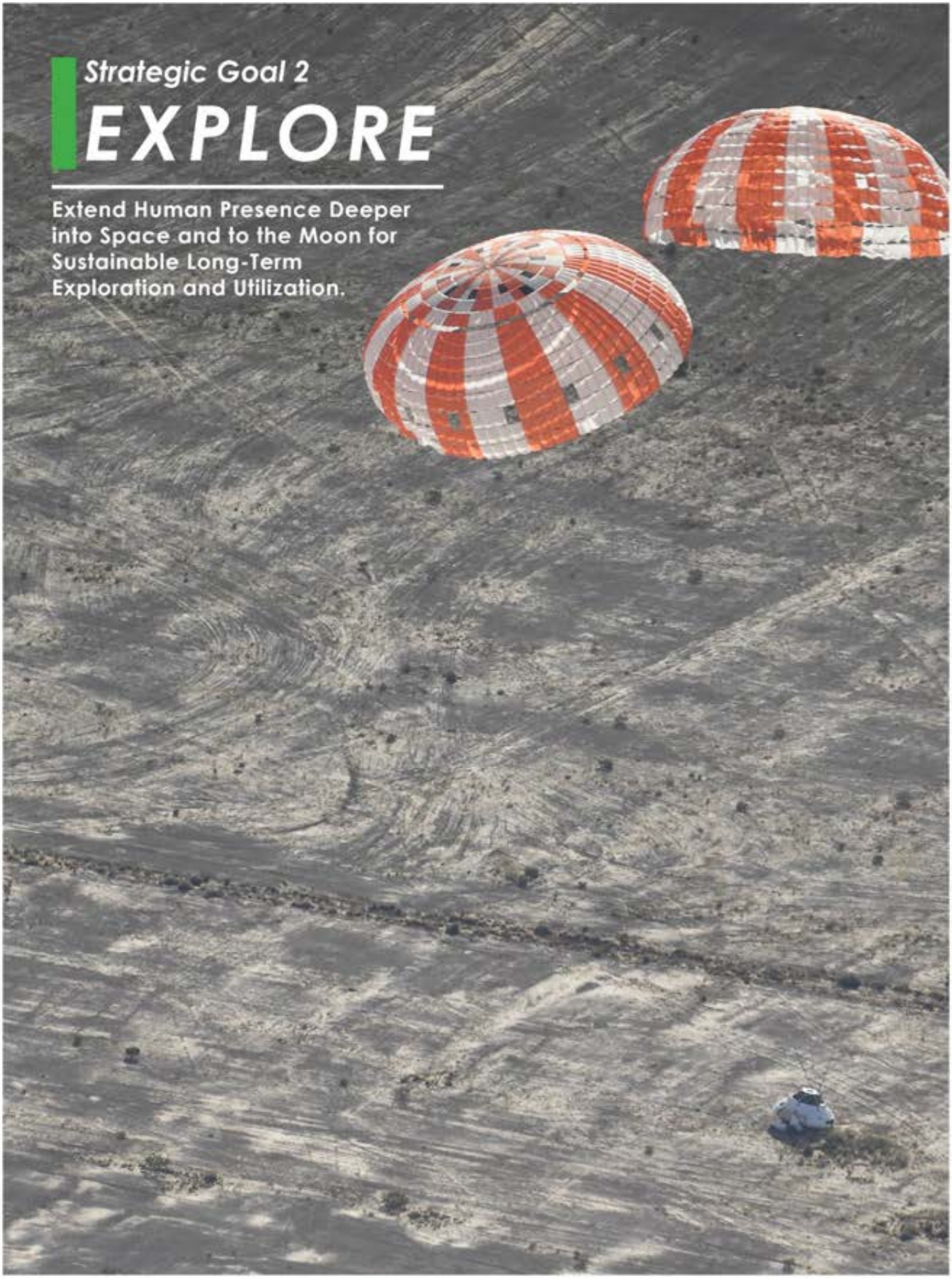
Year	Description
Rating	**Green**
2017	ISS-17-6: Through the Center for the Advancement of Science in Space (CASIS) cooperative agreement, release two solicitations, complete proposal evaluation, and select research projects for International Space Station execution in FY 2017.
2018	ISS-18-4: Through 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.
2019	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.

Annual Performance Indicator 1.2.1: ISS-17-7

Year	Description
Rating	**Green**
2017	ISS-17-7: Produce 500 peer-reviewed publications from projects in human research, space biology, and physical sciences.
2018	ISS-18-5: Enable the production of 500 peer-reviewed publications from spaceflight and ground projects in human research, space biology, and physical sciences.
2019	ISS-19-4: Enable the production of 500 peer-reviewed publications from spaceflight and ground projects in human research, space biology, and physical sciences.

Annual Performance Indicator 1.2.1: ISS-18-3

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	No API this fiscal year.



Strategic Goal 2

EXPLORE

Extend Human Presence Deeper into Space and to the Moon for Sustainable Long-Term Exploration and Utilization.

Summary of Performance for Strategic Goal 2

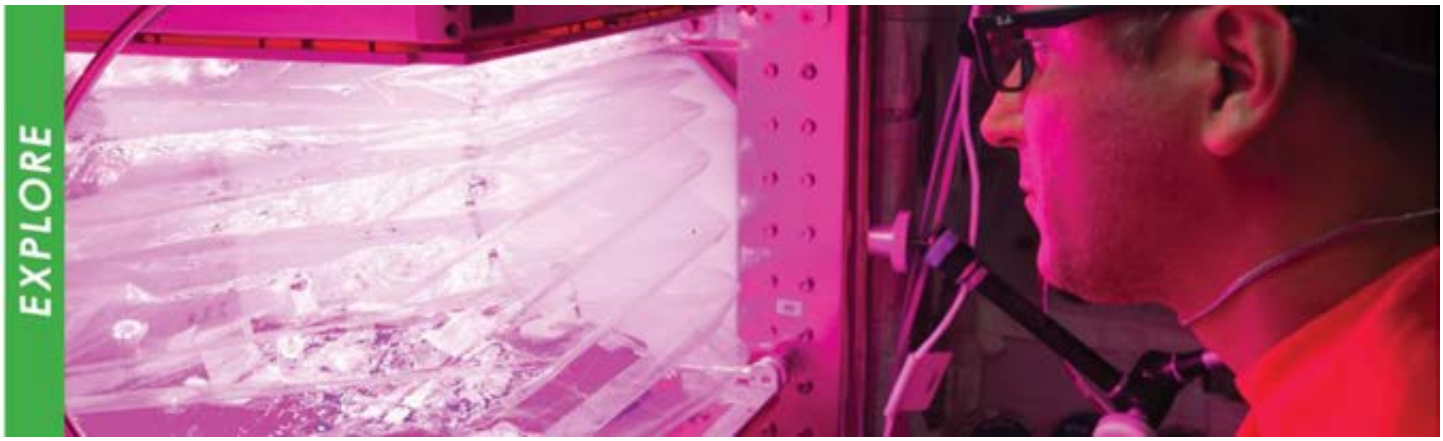
Both strategic objectives included in Strategic Goal 2 are led by the Human Exploration and Operations Mission Directorate (HEOMD). The FY 2017 ratings are summarized below. The following pages describe performance progress for FY 2017 and provide performance plans for FY 2018 and FY 2019.

Performance Goal Ratings by Strategic Objective for FY 2017

Lead	Strategic Objective	Performance Goals				
		Total	Green	Yellow	Red	White
HEOMD	2.1	2	2	0	0	0
HEOMD	2.2	5	3	2	0	0
Total		**7**	**5**	**2**	**0**	**0**
Summary			**71%**	**29%**	**0%**	**0%**

Annual Performance Indicator Ratings by Strategic Objective for FY 2017

Lead	Strategic Objective	Annual Performance Indicators				
		Total	Green	Yellow	Red	White
HEOMD	2.1	2	2	0	0	0
HEOMD	2.2	7	6	2	0	1
Total		**11**	**8**	**2**	**0**	**1**
Summary			**73%**	**18%**	**0%**	**9%**



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)

Contributing Programs/Projects:
International Space Station (ISS) Systems Operations and Maintenance, Human Space Flight Operations

Goal Leader:
Mark Geyer, Acting Deputy Associate Administrator, Technical, HEOMD

Objective Overview

NASA is using its resources to extend human presence in the solar system, as well as foster an emerging and robust commercial space market. The operation of a platform in low Earth orbit for research and technology demonstration is critical to achieving NASA's and the Nation's goals in science, technology, and human space flight.

The ISS is an experiential testing ground and is currently the world's only microgravity laboratory of its kind, enabling the discovery and development of advanced robotics, materials, communications, medicine, agriculture, and environmental science.

Results of research projects on the ISS will continue to yield benefits in areas such as human health, telemedicine, physical science, Earth observations, space science, and education programs that inspire future scientists, engineers, and space explorers. The Center for the Advancement of Science in Space (CASIS) is the sole manager of the ISS National Laboratory, which by law is 50 percent of the resources of the U.S. portion of the ISS, and is working to maximize use of the ISS for research in space. Furthermore, human exploration activities on the ISS will leverage the station as a testbed to demonstrate key exploration capabilities and operations and enable the move to deep space. Directly supporting the ISS until 2025 allows NASA to maximize its potential and maintain American leadership in space. After 2025, the United States will cease directly funding the ISS, but will continue to conduct research, technology development, and other activities in low Earth orbit in conjunction with commercial and international partners. NASA will be a reliable customer for commercial goods and services that support and enhance NASA missions and requirements both in low Earth orbit and in deep space.

Critical to this objective is the selection, training, readiness, and health of crew members. All aspects of astronaut crew health are managed as part of this objective, including implementation of a comprehensive health care program for astronauts, and the prevention and mitigation of negative long-term health

consequences of spaceflight. Through these efforts, NASA will maintain healthy, well-trained astronaut corps of sufficient size to meet all planned mission needs.

NASA's vision for low Earth orbit in the future is a self-sustaining space-based marketplace that provides economic benefits to the Nation and societal benefits to people on Earth. The vision is one where NASA is one of many customers of privately-owned human-tended or permanently-crewed platforms and transportation capabilities that enable a variety of activities in low Earth orbit, where those platforms and capabilities are sustained primarily by commercial revenue rather than relying on NASA and the U.S. Government for their main source of revenue. With this vision, NASA will be able to maximize its resources toward missions beyond low Earth orbit, while still having the ability to utilize low Earth orbit for its ongoing needs.

Strategic Objective 2.1 Data Summary

Performance Goal Ratings (2.1.1 - 2.1.3)

Fiscal Year	Total	Green	Yellow	Red	White
2017	2	2	0	0	0
2016	2	2	0	0	0
2015	2	2	0	0	0
2014	2	2	0	0	0
2013	1	1	0	0	0
2012	1	1	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	2	2	0	0	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 2.1.1

Maintain capability for five or six on-orbit crew members.

2017 Performance Results
Green

The International Space Station (ISS) enables humanity to have an ongoing presence in space, and allows crew members to conduct scientific and technological research that could not be completed anywhere else. As NASA continues to prepare for the next great era of space exploration, extending humanity's reach beyond low Earth orbit for long-term research and study of the Moon, Mars, asteroids, and other bodies across the solar system, the ISS is being used to conduct medical and microgravity experiments and to test the systems that will be required for long-duration space missions.

NASA and its international partners maintained a crew of six on board the ISS for all of FY 2017, except during scheduled crew rotation periods. Crew members rotated approximately every five-to-six months on the Russian Soyuz spacecraft. Crew members represented the United States, Russia, Japan, France, and Italy. All of the required resupply flights, logistics, systems, and operational procedures continued to support a safe and effective ISS platform in space.

Performance Goal 2.1.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 2.1.1)

Year	Description
2018	2.1.1: Increase the crew time for research and development beyond the three U.S. Orbital Segment crew baseline.
2019	2.1.1: Increase the crew time for research and development beyond the three U.S. Orbital Segment crew baseline.

Data Quality Elements

Data Source
Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC) and the ISS Program Quarterly Reviews.

Verification and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.1.1 Annual Performance Indicators

Annual Performance Indicator 2.1.1: ISS-17-2

Year	Description
Rating	**Green**
2017	ISS-17-2: In concert with International Partners, maintain a continuous five- or six-crew capability on the International Space Station by coordinating and managing resources, logistics, systems, and operational procedures.
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.
2019	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.

Annual Performance Indicator 2.1.1: ISS-18-2

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	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.

Performance Goal 2.1.2

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

2017 Performance Results
Green

The Human Space Flight Operations (HSFO) program supports the training, readiness, and health of crew members prior to, during, and after each spaceflight mission to the International Space Station (ISS). All crews on board the ISS have undergone rigorous preparation, which is critical to mission success. The HSFO program provides astronaut selection and training, and manages all aspects of astronaut crew health, including maintenance of a healthy and productive crew during all phases of spaceflight missions, implementation of a comprehensive health care program for astronauts, and the prevention and mitigation of potential negative long-term health consequences of spaceflight. The program also provides expert medical input to program boards, flight rule recommendations, U.S. and international training to both flight and ground crews, medical care guideline requirements for space health care systems, and physical strength conditioning and rehabilitation for crew members.

Throughout FY 2017, the astronaut corps was sized appropriately, met all mission needs, and met all health and training standards.

Additionally, NASA recently announced the selection of 12 new astronaut candidates, following a rigorous selection process from a record-setting applicant pool. Out of more than 18,000 applicants, 120 were selected for round one of the evaluation process. This number was reduced to 50 for round two. Crew Health and Safety (CHS) personnel conducted approximately 620 medical tests, initiated 13 referrals, and used more than 10,000 hours of medical testing to help select the healthiest candidates. CHS modified its assessment procedures to improve the efficiency of testing without sacrificing the quality of the evaluations. The result of the entire selection process is an astronaut candidate class consisting of five women and seven men ranging in age from 29 to 42 years of age, with backgrounds ranging from engineering to medicine.

Performance Goal 2.1.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Green

Planned Future Performance (PG 2.1.2)

Year	Description
2018	2.1.2: Ensure vital assets are ready, available, and appropriately sized to conduct NASA's Mission.
2019	2.1.2: Ensure vital assets are ready, available, and appropriately sized to conduct NASA's Mission.

Data Quality Elements

Data Source
Center level analysis and schedules.

Verification and Validation
The Directorate Program Management Council is the governing body for review of this performance goal.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.1.2 Annual Performance Indicators

Annual Performance Indicator 2.1.2: SFS-17-1

Year	Description
Rating	**Green**
2017	SFS-17-1: Ensure the astronaut corps meets all mission-related training requirements and mission-related health standards.
2018	SFS-18-1: Ensure the astronaut corps meets all mission-related training requirements and mission-related health standards.
2019	SFS-19-1: Ensure the astronaut corps meets all mission-related training requirements and mission-related health standards.

Performance Goal 2.1.3

Does not trend until FY 2018.

2017 Performance Results
N/A

This is a new performance goal in FY 2018.

Performance Goal 2.1.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 2.1.3)

Year	Description
2018	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.
2019	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 Quality Elements

Data Source
To be determined.

Verification and Validation
To be determined.

Data Limitations
To be determined.

Performance Goal 2.1.3 Annual Performance Indicators

Annual Performance Indicator 2.1.3: ISS-18-9

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	ISS-18-9: Issue an Announcement for Proposals (AFP) for the commercial use of low Earth orbit (LEO) for ongoing human spaceflight activities.
2019	ISS-19-10: Award one or more proposals for the commercial use of low Earth orbit (LEO) for ongoing human spaceflight activities.

Annual Performance Indicator 2.1.3: ISS-18-13

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	ISS-18-13: Release a policy document on the commercial use of the International Space Station (ISS).
2019	No API this fiscal year.

Annual Performance Indicator 2.1.3: ISS-19-11

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	ISS-19-8: Deliver the commercial airlock for launch integration on the International Space Station (ISS).

Annual Performance Indicator 2.1.3: ISS-18-10

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	ISS-18-10: Add at least two new in-orbit commercial International Space Station (ISS) facilities and/or facility managers during FY 2018.
2019	ISS-19-12: Add at least two new in-orbit commercial International Space Station (ISS) facilities and/or facility managers during FY 2019.

Annual Performance Indicator 2.1.3: ISS-18-11

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	ISS-18-11: Sign agreements with at least 20 new National Laboratory customers during FY 2018.
2019	ISS-19-11: Sign agreements with at least 20 new National Laboratory customers during FY 2019.

Annual Performance Indicator 2.1.3: ISS-18-12

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	ISS-18-12: Sign agreements with at least 15 repeat National Laboratory customers during FY 2018.
2019	ISS-19-13: Sign agreements with at least 15 repeat National Laboratory customers during FY 2019.

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:
Mark Geyer, Acting Deputy Associate Administrator, Technical, HEOMD

Contributing Programs/Projects:
Orion, Exploration Ground Systems, Human Research Program (HRP), Exploration Advanced Systems, Space Launch System (SLS), International Space Station (ISS), Lunar Orbital Platform – Gateway, Advanced Cis-lunar and Surface Capabilities, Lunar Discovery and Exploration Program

Objective Overview

NASA will lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations. To support this approach, NASA is developing the capability to transport humans to and from deep space and enabling the exploration of the solar system using innovative, advanced technologies and partnerships. NASA is now developing unique new systems, including the Orion crew capsule and the SLS heavy-lift launch vehicle, for transporting people and cargo beyond low Earth orbit. NASA is also defining other elements that would be needed to support missions to the Moon, and to Mars and beyond. Precursor robotic missions that investigate candidate destinations and provide vital information for human explorers will lay the groundwork for deep-space exploration.

Sending astronauts into space involves a multitude of complicated systems, but perhaps the most complex system is the human system. HRP is responsible for understanding and mitigating the highest risks to astronaut health and performance to ensure that crews remain healthy and productive during long-duration missions beyond low Earth orbit. HRP leverages the talents of researchers within NASA and across U.S. academia to implement a detailed plan for risk reduction, with much of this work taking place aboard the ISS. As NASA prepares to conduct crewed missions in cis-lunar space and on the Moon, and eventually at other locations including Mars, HRP biomedical research and technological development are enabling the Agency to safely send humans into deep space for these longer durations.

NASA is increasing its capabilities for safely surviving in deep space for long durations to enable permanent, long-term human space presence in the solar system. This deep space exploration can generate new knowledge and other new applications by scientists and entrepreneurs here on Earth.

Strategic Objective 2.2 Data Summary

Performance Goal Ratings (2.2.1 - 2.2.4)

Fiscal Year	Total	Green	Yellow	Red	White
2017	5	3	2	0	0
2016	5	3	2	0	0
2015	5	2	3	0	0
2014	4	4	0	0	0
2013	2	2	0	0	0
2012	2	2	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	9	6	2	0	1

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 2.2.1

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

2017 Performance Results
Yellow

NASA made significant progress towards its agency priority goal (APG) in FY 2017, but did not complete the goal during the fiscal year. Exploration Systems Development (ESD) completed two of three critical milestones toward its APG, for the Space Launch System (SLS) and Orion spacecraft. The Exploration Ground Systems (EGS) program did not complete its programmatic milestone of completing modifications to Launch Pad 39B, in FY 2017. The milestone was delayed to early FY 2018. This delay did not impact the critical path for Exploration Mission (EM)-1, which will be the first un-crewed flight test of SLS with the Orion spacecraft.

NASA is developing the Nation's first human deep-space exploration capability with SLS and the Orion spacecraft. With the support of the EGS program, SLS and Orion will enable astronauts to travel deeper into the solar system than ever before, including to the Moon, and are essential for the exploration of deep space.

During FY 2017, NASA successfully completed testing on all four SLS Core Stage RS-25 rocket engines for EM-1. NASA also tested the engine controller units, which provide the precision control between the engine and SLS, and allow NASA to run diagnostics on the "health" of the rockets. In its initial configuration, SLS will use the four RS-25 engines to power its Core Stage, along with two solid rocket boosters. A single RS-25 engine produces a thrust in excess of 500,000 pounds for roughly eight minutes. During ignition, temperatures in the engines reach roughly 6,000 degrees Fahrenheit. The RS-25 is one of the most extensively-tested and reliable engines available, having been used for the 30-year operation of the Space Shuttle program. The engines were delivered to the Stennis Space Center in preparation for their need date at the nearby Michoud Assembly Facility in FY 2018.

In addition, NASA completed installation of the Crew Module avionics on the Orion EM-1 flight article, and powered on the article on August 11, 2017. The initial EM-1 test flight will be un-crewed, as part of the Orion test program to develop the spacecraft that will take humans farther into space than they've ever gone before. Orion will serve as the exploration vehicle that will carry the crew to space, provide emergency abort capability, sustain the crew during space travel, and provide safe re-entry from deep space return velocities. During FY 2018, NASA will continue functional tests of the Orion EM-1 flight article at the Kennedy Space Center.

As noted above, the EGS program did not complete its planned milestone in FY 2017. While the program made significant progress on planned upgrades and modifications to Launch Pad 39B (Pad B) at Kennedy Space Center, final completion was delayed into early FY 2018. The EGS program is modernizing Pad B, which was constructed in the 1960s for the Apollo program, so that it can support the launch of EM-1. This has included the refurbishment of the launch pad's heating, ventilation, and air conditioning (HVAC) systems; installation of new potable and non-potable system piping within the pad's perimeter; installation of a new, state-of-the-art communications system; and restoration of the flame trench beneath the pad with new, heat-resistant bricks designed to withstand the extreme temperatures that will be released during the ignition of the SLS RS-25 rocket engines and solid rocket boosters. NASA installed the final brick of the flame trench on May 9, 2017.

Performance Improvement Plan

As noted previously, NASA did not complete the construction of EGS Pad B during FY 2017 as originally planned. Final completion was delayed until early FY 2018.

Performance Goal 2.2.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Yellow	Green	Yellow

Planned Future Performance (PG 2.2.1)

Year	Description
2018	2.2.1: Achieve critical milestones in development of new systems for the human exploration of deep space. (Agency Priority Goal)
2019	2.2.1: Achieve critical milestones in development of new systems for the human exploration of deep space. (Agency Priority Goal)

Data Quality Elements

Data Source
Schedules and Quarterly Program Status Report (QPSR) packages.

Verification and Validation
Review by the Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.2.1 Annual Performance Indicators

Annual Performance Indicator 2.2.1: ESD-17-1

Year	Description
Rating	Green
2017	ESD-17-1: Deliver all four Exploration Mission-1 Space Launch System (SLS) Core Stage RS-25 engines to the Michoud Assembly Facility in preparation for Core Stage integration.
2018	ESD-18-1: Complete production of the Exploration Mission-1 Core Stage liquid oxygen tank.
2019	ESD-19-1: Perform the green run hot-fire test of the Space Launch System's Core Stage at the Stennis Space Center.

Annual Performance Indicator 2.2.1: ESD-17-2

Year	Description
Rating	Green
2017	ESD-17-2: Install avionics and power on Orion Exploration Mission-1 flight article in the Armstrong Operations and Checkout Building at the Kennedy Space Center.
2018	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.
2019	ESD-19-2: Conduct the Ascent Abort-2 test of the Orion Launch Abort System.

Annual Performance Indicator 2.2.1: ESD-17-3

Year	Description
Rating	**Yellow**
2017	ESD-17-3: Complete construction of Exploration Ground Systems (EGS) Pad B.
2018	ESD-18-3: Complete integrated verification and validation testing of the Mobile Launcher and the Vehicle Assembly Building.
2019	ESD-19-3: Roll the Mobile Launcher to the Vehicle Assembly Building to support the start of Exploration Mission-1 stacking operations.

Explanation of Rating

As stated above, NASA completed work on Launch Pad 39B approximately two months after the end of FY 2017.

Performance Goal 2.2.2

Does not trend until FY 2019.

2017 Performance Results
N/A

This is a new performance goal in FY 2019.

Performance Goal 2.2.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 2.2.2)

Year	Description
2018	No PG this fiscal year.
2019	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.

Data Quality Elements

Data Source
Industry partner-provided data to verify accomplishment of milestones.

Verification and Validation
Review of contractually-binding technical milestones.

Data Limitations
Data are sufficiently accurate for their intended use. Some of the data developed by NASA's commercial partners may be protected under intellectual property law.

Performance Goal 2.2.2 Annual Performance Indicators

Annual Performance Indicator 2.2.2: ERD-19-1

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	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 cis-lunar habitats with industry and international partner participation, and develop the final reference configuration for the acquisition phase.

Performance Goal 2.2.3

Advance engineering, technology, and science research.

2017 Performance Results
Green

During FY 2017, the International Space Station (ISS) supported a robust research and development program, allowing NASA to achieve its planned research objectives to advance engineering, technology, and scientific research.

The actual assigned crew hours research activities for ISS Expeditions 49 and 50, covering the period from roughly September 2016 through April 2017, greatly exceeded plan. As a result, the crew implemented the majority of available science, including reserve science. The crew hours for ISS Expeditions 51 and 52 also exceeded the planned research hours. During their rotations, the expected research time of 45.6 hours per week was significantly increased, to an average of 63.2 hours per week.

From July 17-20, 2017, the American Astronautical Society and the Center for the Advancement of Science in Space (CASIS), in cooperation with NASA, hosted the sixth annual ISS Research and Development Conference in Washington, DC. The conference brought together leaders from industry, academia, and government to discuss the latest innovations and breakthroughs in microgravity research, life sciences, materials development, technology development, and human health and remote sensing, as well as the potential applications for space-based research and the economic benefits of increased commercial activity in low Earth orbit. NASA astronaut Kate Rubins, who was the first person to sequence DNA in space, gave a keynote presentation.

In addition, the Agency completed the selection and award of the contract for the first year of the NASA Translational Research Institute (NTRI), and had all key staff on board by the end of FY 2017. NASA is operating the NTRI in partnership with Baylor College of Medicine in Houston, TX. The NTRI will research and develop innovative approaches to reduce risks to humans on long-duration exploration missions.

Performance Goal 2.2.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Yellow	Green	Green

Planned Future Performance (PG 2.2.3)

Year	Description
2018	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)
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)

Data Quality Elements

Data Source
Press releases and program-internal documents indicating whether or not NASA has initiated its planned in-space technology demonstrations.

Verification and Validation
NASA monitors and tracks its progress towards this goal using various Agency documents and reports, including materials from the Advanced Exploration Systems (AES) and ISS program reviews, project schedules, and other program-internal documents. NASA also issues press releases for its major technology demonstration experiments.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.2.3 Annual Performance Indicators

Annual Performance Indicator 2.2.3: ISS-17-3

Year	Description
Rating	**Green**
2017	ISS-17-3: Accomplish a minimum of 90 percent of the on-orbit research and technology development objectives.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 2.2.3: ERD-17-5

Year	Description
Rating	**Green**
2017	ERD-17-5: Complete the selection and implementation of the contract for the first year of the Translational Research Institute to support the translation of cutting edge research into risk mitigation systems for human exploration missions.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 2.2.3: ERD-18-2

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	ERD-18-2: Deliver both the Spacecraft Atmosphere Monitor and Brine Water Processor to the International Space Station (ISS) for technology demonstrations.
2019	ERD-19-2: Deliver the Universal Waste Management System (UWMS) for flight on the International Space Station (ISS).

Annual Performance Indicator 2.2.3: ERD-18-5

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	No API this fiscal year.

Annual Performance Indicator 2.2.3: ISS-18-8

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	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).

Annual Performance Indicator 2.2.3: ERD-19-3

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	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.

Performance Goal 2.2.4

Complete Design Reviews for planetary In-Situ Resource Utilization Demonstrations.

2017 Performance Results
Green

NASA's Advanced Exploration Systems (AES) program pioneers innovative approaches and public-private partnerships to rapidly develop prototype systems, demonstrate key capabilities, and validate operational concepts for future human missions beyond low Earth orbit. The AES program focuses on crew safety and mission operations in deep space, and its activities are strongly coupled to vehicle development. Early integration and testing of prototype systems reduces risk and improves the affordability of exploration mission elements.

NASA is planning a robotic mission to Mars in 2020 to further address key questions about the potential for life on Mars. The Mars 2020 mission will explore a site likely to have been habitable, seek signs of past life, fill a returnable cache with the most compelling samples, and demonstrate technology needed for the future human and robotic exploration of Mars. This includes a demonstration of in-situ resource utilization (ISRU) technologies to produce propellant and consumable oxygen from the Martian atmosphere. With the successful completion of the Critical Design Review in May 2017, the Mars Oxygen ISRU Experiment (MOXIE) team has demonstrated that the project design has the ability to meet requirements with appropriate margins and acceptable risk within defined project constraints. The project has begun the system maturation to continue with the final design and fabrication phase.

Performance Goal 2.2.4 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Yellow	Green

Planned Future Performance (PG 2.2.4)

Year	Description
2018	2.2.4: Develop planetary In-Situ Resource Utilization technologies.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Link(s) to press releases and Design Review Board documents.

Verification and Validation
Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC) and NASA Policy Directive (NPD) 7120.8 or tailored 7120.5 for the ISRU payload.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.2.4 Annual Performance Indicators

Annual Performance Indicator 2.2.4: ERD-17-2

Year	Description
Rating	**Green**
2017	ERD-17-2: Complete the Critical Design Review for the Mars Oxygen ISRU (In-Situ Resource Utilization) Experiment (MOXIE).
2018	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.
2019	No API this fiscal year.

Performance Goal 2.2.5

Does not trend until FY 2018.

2017 Performance Results
N/A

This is a new performance goal in FY 2018.

Performance Goal 2.2.5 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 2.2.5)

Year	Description
2018	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.
2019	2.2.5: Achieve milestones in the early design of a Power and Propulsion Element in partnership with industry.

Data Quality Elements

Data Source
To be determined.

Verification and Validation
To be determined.

Data Limitations
To be determined.

Performance Goal 2.2.5 Annual Performance Indicators

Annual Performance Indicator 2.2.5: ERD-18-6

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	ERD-19-4: In partnership with industry, conduct one or more Preliminary Design Reviews for the Power and Propulsion Element.

Legacy Performance Goal*

Incorporate autonomous controls in life support subsystems testing to increase performance and reliability.

2017 Performance Results
Yellow

**Performance Goal 1.1.5 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 Strategic Plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 2.2. (This performance goal, 1.1.5, aligns to the* 2014 Strategic Plan *framework.)*

NASA's Advanced Exploration Systems (AES) program is developing advanced life support systems that will enable human exploration beyond low Earth orbit. NASA's Life Support Systems (LSS) activities are developing the capabilities to sustain humans who are living and working in space, away from the Earth's protective atmosphere and resources like oxygen, water, and food. This includes monitoring atmospheric pressure, oxygen levels, waste management, and water supply, as well as fire detection and suppression. Currently, a robust international supply chain provides astronauts on the International Space Station (ISS) with life-sustaining supplies. The LSS activities are advancing technologies that will enable crews to travel further from Earth with reduced reliance on resupply missions from home. The further humankind goes from the Earth, the greater the need will be to fully recycle oxygen and water through "closed loop" recycling and recovery systems.

Building on work over the last several years to integrate water recovery and air revitalization systems with control algorithms, the AES program developed algorithms to detect faults that discern false positives and false negatives during the operation of the Plasma Pyrolysis Assembly (PPA). The PPA extracts hydrogen from methane and helps to minimize life support resupply costs for extended duration missions. In test runs lasting hours, no false positives or false negatives were detected. The algorithms were developed using large datasets of the PPA in operation. Detecting faults early in LSS hardware will improve both system performance and system availability. If faults are detected before full system failure, astronauts can elect to make a repair and improve or restore overall system performance. Improvements in system availability arise when the repair or replacement of a degraded component is quicker or simpler than the repair or replacement of a fully failed component, thus getting the system back to full operations more quickly.

By the end of FY 2016, the project had reliably detected process failure faults; however testing had not yielded conclusive process improvement protocols (i.e., the quantity of hydrogen recovered from methane, which leads to increased recovery of oxygen). During FY 2017, NASA generated more datasets representing carbon buildup in the PPA vacuum chamber. NASA made substantial progress in characterizing the failure detection before the onset of carbon deposition, which was validated with more experimental runs and the incorporation of the fault systems that feed into the PPA. However, NASA was unable to gather enough datasets to validate multi-fault detection and recovery modes.

Performance Goal 1.1.5 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	Green	Yellow	Yellow

Planned Future Performance (PG 1.1.5)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Schedules and Quarterly Program Status Report (QPSR) packages.

Verification and Validation
Review by the Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.1.5 Annual Performance Indicators

Annual Performance Indicator 1.1.5: ERD-17-3

Year	Description
Rating	**White**
2017	ERD-17-3: Complete the manufacture and assess the performance of the Portable Life Support System (PLSS) 2.5.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 1.1.5: ERD-17-4

Year	Description
Rating	**Yellow**
2017	ERD-17-4: Integrate autonomous controls with different life support subsystems and conduct a system-level test to demonstrate increased system efficiency.
2018	No API this fiscal year.
2019	No API this fiscal year.

Legacy Performance Goal*

Increase the occupancy of the International Space Station's (ISS's) internal and external research facilities by adding new instruments and capabilities. (Agency Priority Goal)

2017 Performance Results
Green

**Performance Goal 1.2.1 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 Strategic Plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 2.2. (This performance goal, 1.2.1, aligns to the* 2014 Strategic Plan *framework.)*

NASA successfully completed this agency priority goal (APG) in FY 2017, increasing the occupancy of the International Space Station (ISS) to over 79 percent. The ISS is the world's only continuously-crewed, microgravity research and development laboratory in orbit. NASA is increasing the occupancy of the ISS to conduct scientific research, for exploration-related technology development, and to foster commercial investment in space. Increasing facility occupancy is a function of the demand for the use of the ISS, which is driven by the funding of research by NASA, other Government agencies, and the private sector; and the capacity of the laboratory to support research, which is determined by the infrastructure in orbit, the transportation system, and the crew availability.

During FY 2017, the following payloads were launched to the ISS:

- On October 17, 2016, Orbital ATK launched its Commercial Resupply Services (CRS)-5 mission on a Cygnus vehicle with approximately 5,300 pounds of supplies and science experiments, including the Spacecraft Fire Safety (Saffire) II payload experiment to study combustion in microgravity.
- On February 19, 2017, the Space Exploration Technologies Corporation (SpaceX) launched its CRS-10 mission on a Dragon vehicle with approximately 5,500 pounds of payload and payload resupply, including the Stratospheric Aerosol and Gas Experiment (SAGE) III, which is collecting data on ozone, aerosols, water vapor, and other gases in Earth's atmosphere.
- On April 18, 2017, Orbital ATK launched its CRS-7 mission on a Cygnus vehicle with over 7,600 pounds of supplies and science investigations, including the Advanced Plant Habitat, which will be used to conduct plant bioscience research and help prepare crew to grow their own food in space during deep-space exploration missions.
- On June 3, 2017, SpaceX launched its CRS-11 mission on a Dragon vehicle with almost 6,000 pounds of science research, crew supplies, and hardware, including the Neutron star Interior Composition Explorer (NICER). NICER will provide high-precision measurements of neutron stars, which are objects containing ultra-dense matter at the threshold of collapsing into black holes.
- On August 14, 2017, SpaceX launched its CRS-12 mission on a Dragon vehicle with approximately 6,400 pounds supplies and payloads, including the Cosmic-Ray Energetics and Mass (CREAM). ISS-CREAM will replicate similar, ground-based experiments to measure cosmic rays, which are high-speed, high-energy particles from space, but at an altitude high enough to eliminate the obscuring effects of the atmosphere.

Performance Goal 1.2.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Yellow	Green	Green

Planned Future Performance (PG 1.2.1)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Schedules and Quarterly Program Status Report (QPSR) packages.

Verification and Validation
Review by the Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.2.1 Annual Performance Indicators

Annual Performance Indicator 1.2.1: ISS-17-1

Year	Description
Rating	**Green**
2017	ISS-17-1: By the end of FY 2017, increase the occupancy of the International Space Station's internal and external research facilities to 75 percent.
2018	No API this fiscal year.
2019	No API this fiscal year.

Strategic Goal 3

DEVELOP

Address National Challenges and Catalyze Economic Growth.

Summary of Performance for Strategic Goal 3

Strategic Goal 3 includes strategic objectives led by Exploration Research & Technology (ER&T),[7] the Aeronautics Research Mission Directorate (ARMD), and the Office of Communications (OCOM), which is part of the Mission Support Directorate. The FY 2017 ratings are summarized below. The following pages describe performance progress for FY 2017 and provide performance plans for FY 2018 and FY 2019.

Performance Goal Ratings by Strategic Objective for FY 2017

Lead	Strategic Objective	Performance Goals				
		Total	Green	Yellow	Red	White
ER&T	3.1	4	3	1	0	0
ARMD	3.2	6	4	2	0	0
OCOM	3.3	7	7	0	0	0
Total		**17**	**14**	**3**	**0**	**0**
Summary			**82%**	**18%**	**0%**	**0%**

Annual Performance Indicator Ratings by Strategic Objective for FY 2017

Lead	Strategic Objective	Annual Performance Indicators				
		Total	Green	Yellow	Red	White
ER&T	3.1	7	5	1	1	0
ARMD	3.2	10	8	1	1	0
OCOM	3.3	9	9	0	0	0
Total		**26**	**22**	**2**	**2**	**0**
Summary			**85%**	**8%**	**8%**	**0%**

[7] FY 2017 performance was completed by the Space Technology Mission Directorate.

Strategic Objective 3.1

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

Lead Office:
Exploration Research & Technology (ER&T)

Goal Leader:
Dr. Prasun Desai, Deputy Associate Administrator for Management, ER&T

Contributing Programs/Projects:
Early Stage Innovation & Partnerships, Technology Maturation, Technology Demonstration, Human Research Program, Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)

Objective Overview

Through the decades, NASA's technology development and transfer have enabled important space science and exploration missions, contributed to other U.S. Government agencies' needs, cultivated commercial aerospace enterprises, and helped foster a technology-based U.S. economy. *Rising Above the Gathering Storm, Revisited*, a report by the National Academies, addresses the link between technology development efforts and the economy, noting that various studies indicate a strong link between economic growth and technological innovation in recent decades.

Over the next 10 years—through investments within the ER&T funding account—the Agency will advance revolutionary capabilities for both NASA mission challenges and National needs, and also address the market challenges associated with providing state-of-the-art commercial space products and services. More specifically, technology investments within the ER&T funding account will focus on the following thrusts.

- Accelerating large-scale industrialization of space
- Enabling efficient and safe transportation into and through space
- Increasing access to planetary surfaces
- Enabling humans to live and work in space and on planetary surfaces
- Expanding capabilities through robotic exploration and discovery
- Growing and utilizing the U.S. industrial and academic base

To support these strategic investment area thrusts, NASA will primarily invest in the following Exploration Campaign key focus areas: Advanced environmental control and life support systems and in-situ resource utilization; Power and propulsion technology; Advanced materials; Communications, navigation and avionics; Entry, descent, and landing; Autonomous operations; In-space manufacturing and on-orbit assembly; and Research to enable humans to safely and effectively operate in various space environments. In addition, ER&T contributes to growing the U.S. industrial and academic base to continue the Nation's economic leadership.

Strategic Objective 3.1 Data Summary

Performance Goal Ratings (Legacy 1.7.1 – 1.7.4)

Fiscal Year	Total	Green	Yellow	Red	White
2017	4	3	1	0	0
2016	3	3	0	0	0
2015	3	3	0	0	0
2014	3	3	0	0	0
2013	2	2	0	0	0
2012	2	2	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	7	5	1	1	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 3.1.1

Does not trend until FY 2019.

2017 Performance Results
N/A

This is a new performance goal in FY 2019.

Performance Goal 3.1.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 3.1.1)

Year	Description
2018	No PG this fiscal year.
2019	TBD*

* NASA will provide this performance goal, and others as appropriate, in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Performance Goal 3.1.1 Annual Performance Indicators

Annual Performance Indicator 3.1.1: TBD

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	TBD*

* NASA will provide this annual performance indicator, and others as appropriate, in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Legacy Performance Goal*

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

2017 Performance Results
Green

**NASA is restructuring this account to focus on the deep-space mission elements and technology developments needed for sustainable human exploration. Performance Goal 1.7.1 was retired with the* 2014 Strategic Plan *and does not trend into the new* 2018 Strategic Plan *framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 3.1. (This performance goal, 1.7.1, aligns to the* 2014 Strategic Plan *framework.)*

NASA has met this multiyear performance goal as the Agency continues to advance early stage innovation. The Space Technology Mission Directorate (STMD) developed the crosscutting new technologies and capabilities needed by the Agency to achieve its current and future missions. NASA made significant progress in the following areas:

Accelerating Development through Research Grants
NASA STMD accelerated the development of low technology readiness level space technologies to support future space science and exploration needs. Implementation of this approach included selection of research grants through competitive solicitations for proposals from accredited U.S. universities. Through NASA Space Technology Research Fellowships, Early Stage Innovations awards, and Early Career Faculty awards, STMD engaged a broad spectrum of academic researchers, from graduate researchers to senior faculty members. In FY 2017, NASA selected:

- 66 NASA Space Technology Research Fellowships;
- 13 Early Stage Innovations awards; and
- 8 Early Career Faculty awards.

More information is available on the Space Technology Research Grants website.

Investing in Innovative and Advanced Concepts
NASA invested in concepts with the potential to transform future aerospace missions, enable new capabilities, or significantly alter and improve current approaches. In FY 2017, NASA:

- Selected 22 new innovative concept studies comprising 15 Phase I projects and 7 Phase II projects; and
- Made excellent progress developing innovative concept studies selected in prior fiscal years.

More information is available on the NASA Innovative Advanced Concepts website.

Encouraging Innovation within NASA's Centers
NASA encouraged creativity and innovation within the NASA Centers by supporting emerging technologies and creative initiatives that leverage Center talent and capability. During FY 2017, NASA selected and conducted 128 Center Innovation Fund projects. These projects spanned all NASA Centers, all 15 Technology Roadmaps, and all technology areas.

More information is available on the Center Innovation Fund website.

Performance Goal 1.7.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 1.7.1)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Space Technology Research Grants, NASA Innovative Advanced Concepts, and Center Innovation Fund program documentation and press releases.

Verification and Validation
Within STMD, Strategic Planning and Integration (SPI) coordinated and integrated performance goal and annual performance indicator review and evaluation, working closely with portfolio executives, program executives, and program managers responsible for individual performance goals and annual performance indicators. For this performance goal, this process included review of program documentation and press releases for Space Technology Research Grants (STRG), NASA Innovative Advanced Concepts (NIAC), and Center Innovation Fund (CIF). Final ratings and justifications were approved by the SPI Director. During annual program performance status reviews, each program reported applicable performance goal and annual performance indicator ratings and justification to the STMD Program Management Council.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.7.1 Annual Performance Indicators

Annual Performance Indicator 1.7.1: ST-17-1

Year	Description
Rating	Green
2017	ST-17-1: Initiate at least 165 activities to research, study, or develop concepts for new technologies.
2018	No API this fiscal year.
2019	No API this fiscal year.

Legacy Performance Goal*

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

2017 Performance Results
Yellow

**NASA is restructuring this account to focus on the deep-space mission elements and technology developments needed for sustainable human exploration. Performance Goal 1.7.2 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 3.1. (This performance goal, 1.7.2, aligns to the 2014 strategic plan framework.)*

Although the Space Technology Mission Directorate (STMD) rated its annual performance indicator red for FY 2017 (see ST-17-4, below), it made progress towards meeting this multiyear performance goal.

Improving Existing Capabilities and Advancing Promising New Technology Solutions
In FY 2017, STMD Game Changing Development (GCD) continued advancement of many promising technology solutions. Highlighted accomplishments include the following:

Space Exploration for X-ray Timing and Navigation Technology (SEXTANT)
SEXTANT was launched to the International Space Station in July 2017. SEXTANT is being demonstrated with the Neutron star Interior Composition Explorer (NICER) hardware. In collaboration with the Science Mission Directorate, the project was selected as an Explorer Mission of Opportunity. The goal of the SEXTANT/NICER mission will be to investigate pulsars and demonstrate real-time, autonomous spacecraft navigation using pulsars as beacons. Using the coarse calibration data in the ground version of its flight software, the SEXTANT team successfully detected pulsations for Millisecond Pulsars B1821-24, B1937+21, J0218+4232, and J0437-4715. These data were used to create an initial flight software configuration that was uploaded at the end of July, which resulted in the first successful navigation measurement generated in real-time by the onboard flight software.

High Performance Spaceflight Computing (HPSC)
In FY 2017, the HPSC project awarded Processor Chip development to industry. The development phase of HPSC project development will consist of a preliminary design phase culminating in a Preliminary Design Review, a detailed design phase culminating in a Critical Design Review, a fabrication phase, and a test and characterization phase. The project will deliver the following projects: Chiplet software emulator; Chiplet simulation models; prototype processor Chiplets, including packaged parts and bare die that have been tested at ambient temperature; Chiplet evaluation boards; and system software as specified in the HPSC requirements document. Upon completion, development HPSC will provide a significant advancement of computing capability for a wide range of space applications.

Kilopower Small Fission Technology
In FY 2017, the Kilopower small fission technology project successfully completed a final non-nuclear dry run of the Kilopower Experiment assembly and disassembly at the Glenn Research Center's Flight Research Facility. The project developed a mockup of the Nevada National Security Site (NNSS) experiment facility that included the test platform. The Kilopower experiment assembly, including a reactor core simulator, heat pipes, power conversion system, service collar, and vacuum chamber, was assembled and moved into position on the facility test platform mockup. The reflector, made of boron carbide shield materials and aluminum surrogate reflector pieces (standing in for the beryllium oxide reflector pieces already delivered to Nevada), was lifted by a surrogate lift table into place around the reactor core vacuum container, as will be done in stages in a gradual increase in reactivity over several weeks in the NNSS facility until full power is achieved. The experiment was disassembled to ensure that all operations could be conducted with the real experiment parts as designed and tested with the dimensionally-correct surrogate parts. Seven experiment operators from the

NNSS facility observed and participated in the dry run to assure that it adequately demonstrated readiness for the NNSS facility.

Bulk Metallic Glass (BMG) Gears:
In FY 2017, the BMG project completed the commercial fabrication of its planetary gearbox components in order to begin assembly of the project's test vehicles. Those components included ring, planet, planet carrier, and pinion gears. The BMG technology enables cold-capable mechanisms, which means they would enable missions to operate in extremely cold environments or distant targets with limited power availability, like icy bodies or Europa, without the use of heaters to keep the mechanisms warm. The project is on its way, characterizing the life of planetary and strain wave (harmonic) gears at extremely cold temperatures (100 Kelvin) by the end of October 2017.

More information is available on the Game Changing Development website.

Performance Improvement Plan

As stated above, accomplishment of this performance goal relied on accomplishment of the underlying annual performance indicator. During the performance goal's performance period (FY 2014 through FY 2017), GCD received a yellow or red rating for the program's annual performance indicator in FY 2016 and 2017. Please see below for more information.

Performance Goal 1.7.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Yellow

Planned Future Performance (PG 1.7.2)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Evidence will include the list of planned fiscal year milestones, along with completion status.

Verification and Validation
Within STMD, Strategic Planning and Integration (SPI) coordinated and integrated performance goal and annual performance indicator review and evaluation, working closely with portfolio executives, program executives and program managers responsible for individual performance goals and annual performance indicators. For this performance goal, this process included monthly assessment of milestone progress by Game Changing Development, including presentation of status to STMD leadership. Final ratings and justifications were approved by the SPI Director. During annual program performance status reviews, each program reported applicable performance goal and annual performance indicator ratings and justification to the STMD Program Management Council.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.7.2 Annual Performance Indicators

Annual Performance Indicator 1.7.2: ST-17-4

Year	Description
Rating	**Red**
2017	ST-17-4: Complete at least 75 percent of Game Changing Development program milestones, as established at the beginning of the fiscal year.
2018	No API this fiscal year.
2019	No API this fiscal year.

Explanation of Rating

The GCD program targeted completion of 75 percent of 45 identified milestones in the advancement of new technologies. The GCD program completed 51 percent of these milestones—well below the 75 percent target—resulting in a red rating for FY 2017.

STMD made several adjustments to GCD projects throughout FY 2017. These included project de-scoping or deletion due to portfolio difficulty, technical challenges, and other issues.

Legacy Performance Goal*

Mature new crosscutting space technology capabilities for demonstration.

2017 Performance Results
Green

**NASA is restructuring this account to focus on the deep-space mission elements and technology developments needed for sustainable human exploration. Performance Goal 1.7.3 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 3.1. (This performance goal, 1.7.3, aligns to the 2014 strategic plan framework.)*

NASA has met this multiyear performance goal as the Agency continued to mature new crosscutting space technology capabilities for demonstration:

Employing the Unique Features of Small Spacecraft
Through the advancement of small spacecraft, NASA sought to realize mission capabilities that were more rapid, more transformative, and more affordable than previously achievable. As part of this effort, the Space Technology Mission Directorate (STMD) made significant progress in FY 2017 on small spacecraft projects, including completion of major project lifecycle milestones in technology development and demonstration activities:

- Pathfinder Technology Demonstrator Flight 1 System Requirements Review;
- Pathfinder Technology Demonstrator Flight 2 Delta System Requirements Review;
- HYDROS water thruster Preliminary Design Review, Critical Design Review, and Test Readiness Review;
- Hyper-XACT attitude determination and control system Critical Design Review and Test Readiness Review; and
- MPS-130 green propellant thruster Preliminary Design Review.

More information is available on the Small Spacecraft Technology website.

Maturing Crosscutting Technologies to Flight-Ready Status
Charged with proving revolutionary, crosscutting technologies—ones that could radically advance NASA's Mission in space and reap crosscutting benefits for science and industry here on Earth—STMD sought to mature laboratory-proven technologies to flight-ready status. In this area, STMD made significant progress on several Technology Demonstration Missions (TDM) projects in FY 2017:

- Restore-L, System Requirements Review / Mission Design Review (SRR/MDR) and Key Decision Point (KDP)-B, passed in FY 2017 second quarter;
- Evolvable Cryogenics Project (eCryo), Annual Review #2, passed in FY 2017 second quarter;
- Laser Communications Relay Demonstration (LCRD), Critical Design Review and KDP-C, passed in FY 2017 second quarter; and
- In-space Robotic Manufacturing and Assembly (IRMA), Base Period Gate Review, passed in FY 2017 fourth quarter.

More information is available on the Technology Demonstration Missions website.

Performance Goal 1.7.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Green

Planned Future Performance (PG 1.7.3)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Review reports, key decision point (KDP) decision memoranda, or other relevant milestone documentation.

Verification and Validation
Within STMD, Strategic Planning and Integration (SPI) coordinated and integrated performance goal and annual performance indicator review and evaluation, working closely with portfolio executives, program executives, and program managers responsible for individual performance goals and annual performance indicators. For this performance goal, this process included 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 were approved by the SPI Director. During annual program performance status reviews, each program reported applicable performance goal and annual performance indicator ratings and justification to the STMD Program Management Council.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.7.3 Annual Performance Indicators

Annual Performance Indicator 1.7.3: ST-17-5

Year	Description
Rating	**Green**
2017	ST-17-5: Complete three major milestones for small spacecraft projects to demonstrate game changing or crosscutting technologies in space.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 1.7.3: ST-17-6

Year	Description
Rating	**Green**
2017	ST-17-6: Complete four major milestones for Technology Demonstration Mission (TDM) technology development projects.
2018	No API this fiscal year.
2019	No API this fiscal year.

Legacy Performance Goal*

Engage the established commercial sector, emerging aerospace markets, and economic regions to leverage common interests and grow the National economy.

2017 Performance Results
Green

**NASA is restructuring this account to focus on the deep-space mission elements and technology developments needed for sustainable human exploration. Performance Goal 1.7.4 was retired with the* 2014 Strategic Plan *and does not trend into the new* 2018 Strategic Plan *framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 3.1. (This performance goal, 1.7.4, aligns to the* 2014 Strategic Plan *framework.)*

NASA has met this multiyear performance goal as the Agency continued to incentivize and foster innovation and mature new crosscutting space technology capabilities for demonstration:

Incentivizing Innovation through Cash Prizes
NASA provided cash prize incentives to non-traditional sources for innovations of interest and value to the Agency and the Nation. NASA conducted the following Centennial Challenge competitions during FY 2017:

- Cube Quest Challenge: Ground Tournament 3 in FY 2017 first quarter ($150 thousand awarded). Cube Quest Challenge, Ground Tournament 4 in FY 2017 third quarter ($60 thousand awarded).
- Space Robotics Challenge: Qualification Round in FY 2017 second quarter ($270 thousand awarded). Final Virtual Competition in FY 2017 third quarter ($300 thousand awarded).
- 3D Printed Habitat Challenge (Phase 2): Level 1 Competition in FY 2017 fourth quarter ($100 thousand awarded). Level 2 Beam Member Competition in FY 2017 fourth quarter ($201 thousand awarded). Level 3 Head-to-Head Ground Competition in FY 2017 fourth quarter ($400 thousand awarded).

More information is available on the Centennial Challenges website.

Fostering Innovation at Small Businesses
NASA provided opportunities for small, highly innovative companies and research institutions to contribute to NASA's missions, provide societal benefit, and grow the U.S. economy. The Agency accomplished this through its Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs. The SBIR/STTR Programs promoted advancement to and beyond Phase II, working closely with internal and external programs to identify and pursue potential collaborations. In FY 2017, NASA created 25 post-Phase II SBIR/STTR opportunities. These opportunities included Phase II-Enhancement contract options to extend SBIR/STTR R&D in partnership with non-SBIR/STTR funding partners.

More information is available on the SBIR/STTR website.

Providing Flight Opportunities
NASA's Flight Opportunities program strove to advance the operational readiness of crosscutting space technologies while also stimulating the development and utilization of the U.S. commercial spaceflight industry, particularly for the suborbital and small launch vehicle markets. Since its initiation in 2010, the program provided frequent access to relevant space-like environments for over 100 payloads across a variety of flight platforms. During FY 2017, Flight Opportunities flew payloads on flights provided by four commercial providers:

- Masten Space Systems
- Near Space Corporation
- World View Enterprises
- Zero Gravity Corporation

More information is available on the Flight Opportunities website.

Performance Goal 1.7.4 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	Green

Planned Future Performance (PG 1.7.4)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Internet articles, NASA news releases, program spreadsheets, and other relevant documentation stored on a document and records management system.

Verification and Validation
Within the Space Technology Mission Directorate (STMD), Strategic Planning and Integration (SPI) coordinated and integrated performance goal and annual performance indicator review and evaluation, working closely with portfolio executives, program executives and program managers responsible for individual performance goals and annual performance indicators. For this performance goal, this process included review of NASA news releases, Internet articles, and other relevant internal and external program documentation for SBIR/STTR, Centennial Challenges (CC), Prizes and Challenges, Flight Opportunities (FO), and NASA Technology Transfer activities. During annual program performance status reviews, each program reported applicable performance goal and annual performance indicator rating ratings and justification to the STMD Program Management Council.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 1.7.4 Annual Performance Indicators

Annual Performance Indicator 1.7.4: ST-17-2

Year	Description
Rating	Green
2017	ST-17-2: Conduct at least three prize competitions.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 1.7.4: ST-17-3

Year	Description
Rating	Green
2017	ST-17-3: Create 10 opportunities for advancement beyond Phase II SBIR/STTR.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 1.7.4: ST-17-7

Year	Description
Rating	**Yellow**
2017	ST-17-7: Select and fly technology payloads from NASA, other government agencies, industry, and academia using flight services procured from at least five different commercial reusable suborbital or parabolic platform providers.
2018	No API this fiscal year.
2019	No API this fiscal year.

Explanation of Rating

In FY 2017, NASA provided technology demonstration flights using services from four commercial providers: Masten Space Systems, Near Space Corporation, World View Enterprises, and Zero Gravity Corporation. In addition, the Flight Opportunities (FO) program funded and was prepared to fly payloads on platforms from UP Aerospace and Blue Origin. However, due to operational challenges, the commercial providers were unable to support these flights in FY 2017. This resulted in a yellow rating for this annual performance indicator in FY 2017.

In FY 2018 first quarter, NASA anticipates flying an FO payload for the first time on Blue Origin's New Shepard launch vehicle. NASA also anticipates flying an FO payload on UP Aerospace's SpaceLoft XL launch vehicle. These planned flights, in combination with demonstrations planned for Masten Space Systems, Near Space Corporation, World View Enterprises, and Zero Gravity Corporation, will help the program reach its goal of leveraging at least five different providers for technology demonstration.

During FY 2017, NASA announced new public-private partnerships under the FY 2016 Announcement of Collaborative Opportunity (ACO). Three companies will be participating in projects related to ACO Topic 1– Small Launch Vehicle Technology Development, an area of particular interest to the FO program. Through these collaborations, NASA will partner with industry to continue to expand commercial small launch vehicle capabilities, one of the key objectives of the FO program. This activity also has the potential to expand the number of flight providers available to the FO program for technology demonstration in the future, increasing the likelihood that the program can meet this annual performance indicator going forward.

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

Contributing Programs/Projects:
Transformative Aero Concepts, Integrated Aviation Systems, Airspace Operations and Safety, Advanced Air Vehicles

Objective Overview

As a primary mechanism for physically connecting cities and countries across the world, air transportation is an integral part of today's U.S. and global economies. Aviation enables U.S. enterprises to operate on a global scale, providing safe and high-speed transport of people and goods. It accounts for more than $1.6 trillion of U.S. economic activity each year and generates a positive trade balance of $82.5 billion in 2015. The aviation industry also supports more than 11.8 million direct and indirect jobs in the United States, including more than one million high-quality manufacturing jobs. Aviation comprises more than five percent of the total U.S. gross domestic product. Nearly every product created and purchased today has been touched by aviation in some way. Globally, the aviation system is growing rapidly with the potential for more than five times as many passengers and 10 times the cargo in 2050 as today. Since its establishment, NASA has continually advanced America's aviation system to improve humanity's quality of life and productivity on Earth.[8,9]

NASA contributes unique innovations to aviation through research activities. These innovations serve as key enablers for the role of U.S. commercial aviation in sustaining American commerce and safe, environmentally sustainable mobility, and hence the Nation's economic well-being. NASA's role is to explore early stage concepts and ideas, develop new technologies and operational procedures through foundational research, and demonstrate the potential of promising new vehicles, operations, and safety technology in relevant environments. The Agency is focused on appropriate cutting-edge research and technologies to overcome a wide range of aeronautics technical challenges for the Nation's and the world's current and future air transportation systems.

[8] *The Economic Impact of Civil Aviation on the U.S. Economy*, Federal Aviation Administration, June 2014.
[9] *Vision 2050*, International Air Transportation Association, February 2011.

Strategic Objective 3.2 Data Summary

Performance Goal Ratings (3.2.1 - 3.2.6)

Fiscal Year	Total	Green	Yellow	Red	White
2017	6	4	2	0	0
2016	6	6	0	0	0
2015	6	6	0	0	0
2014	6	6	0	0	0
2013	4	4	0	0	0
2012	4	4	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	10	8	1	1	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

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.

2017 Performance Results
Green

NASA's Aeronautics Research Mission Directorate (ARMD) collaborated with industry partners to develop a prototype flight hardware and software component of the Agency's Air Traffic Management (ATM) Technology Demonstration (ATD)-1 research. The prototype system, known as Flight Deck Interval Management (FIM), was installed on two test aircraft for evaluation in a flight test conducted in February 2017. The new cockpit-based air traffic management tool is designed to automatically provide pilots with more precise spacing information on approach into a busy airport so that more planes can safely land in a given time. The technology is intended to help airplanes spend less time in the air, save money on fuel, and reduce engine emissions—all while improving schedule efficiency to help passengers arrive on time. Early analysis indicated that the FIM system was successful. Additional data review will continue, and NASA plans to transfer the prototype FIM system and all associated products to the Federal Aviation Administration (FAA) for further testing by 2018.

In September 2017, Phase 1 of the ATD-2 Integrated Arrival/Departure/Surface (IADS) Baseline Demonstration commenced at Charlotte Douglas International Airport. During the Phase 1 demonstration, American Airlines ramp managers and controllers, as well as FAA traffic control tower managers, began using the ATD-2 IADS system to collaboratively manage Charlotte Douglas International Airport surface traffic to improve the predictability and efficiency of surface operations. The ATD-2 IADS system also will help FAA traffic managers and the Washington Air Route Traffic Control Center to smoothly merge flights departing Charlotte Douglas International Airport into busy northeast corridor overhead traffic flows. The Phase 1 demonstration will proceed through 2018 as a series of multi-stage enhancements, each of which introduces additional capabilities to IADS system users.

NASA is also developing decision support tools designed to assist air traffic flow managers to efficiently update weather avoidance routes after the original re-routes have become outdated due to subsequent evolution of the convective weather system. A human-in-the-loop evaluation of the Multi-Flight Common Route (MFCR) tool was conducted in the Ames Research Center's Air Traffic Control Laboratory in September 2017. MFCR is a NASA-developed concept under the ATD-3 subproject. MFCR groups multiple flights to reduce the number of advisories that the traffic flow manager needs to evaluate, and also merges these flights on a common route segment to provide an orderly flow of re-routed traffic. Four experienced FAA personnel provided feedback on the MFCR tool and its concept of use, such as operational acceptability of MFCR re-route advisories, the usability of MFCR's graphical user interface, and overall viability. Feedback from the subject-matter experts was overall very positive, indicating that MFCR identified many time-saving re-routing opportunities that would be difficult to identify manually during air traffic operations in bad weather conditions.

NASA completed a beta build Testbed for Shadow-Mode Assessment using Realistic Technologies for the National Airspace System (SMART-NAS). The SMART-NAS Testbed enables high-fidelity human-in-the-loop and automation-in-the-loop simulations and tests that are either impractical or impossible today, but are needed to:

- Validate concepts using multiple operational domains, such as gate-to-gate trajectory-based operations;
- Investigate concepts related to revolutionary operations, such as unmanned aircraft systems integration; and

- Provide a high-fidelity test environment for real-time system-wide safety assurance capabilities. The Testbed beta build supports the setup and execution of large-scale simulations. This capability is achieved through the development and implementation of core services, such as integration of the FAA's NAS-wide information system (a critical component of achieving Next Generation Air Transportation System goals), traffic monitoring, aviation weather information, safety hazard alert notifications, and multiple distributed traffic simulators and connectivity to live aircraft via the GovCloud platform.

Performance Goal 3.2.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 3.2.1)

Year	Description
2018	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.
2019	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 Quality Elements

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 and Validation
Measure rating reviewed and approved quarterly by the Program Director and ARMD Associate Administrator (AA).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.1 Annual Performance Indicators

Annual Performance Indicator 3.2.1: AR-17-1

Year	Description
Rating	Green
2017	AR-17-1: Conduct Shadow Mode assessment of departure metering prototypes in the field.
2018	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.
2019	AR-19-1: Develop an initial Trajectory-Based Operations Services (TBOS) concept and architecture design to support access for potential emergent markets and to improve user-negotiated operations for all missions.

Annual Performance Indicator 3.2.1: AR-19-6

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	AR-19-6: Conduct Shadow Mode assessment of Integrated Arrival/Departure/Surface (IADS) metroplex departure metering prototypes.

Performance Goal 3.2.2

Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.

2017 Performance Results
Yellow

Progress towards achieving the goal of demonstrating a reduction in noise from sonic booms and creating opportunities for rule changes to allow quiet overland supersonic fight continued during FY 2017 as the Aeronautics Research Mission Directorate's (ARMD's) Low Boom Flight Demonstration (LBFD) project took several significant steps towards full project execution.

The primary goals of the LBFD effort are to first build a piloted test aircraft designed to fly at supersonic speed while demonstrating the capability of minimizing sonic boom noise. Next, that aircraft will be used to collect data for quiet supersonic overland flight that will enable the replacement of world-wide prohibitions with certification rules based on acceptable sound levels.

On the technical front, the LBFD completed the preliminary design for the test aircraft. This effort called QueSST, short for Quiet Supersonic Technology, addressed integration of all aspects of a design that enables the mission requirements of the LBFD to be met. Scaled models of the design were tested in the Glenn Research Center's wind tunnels in 2017 to validate the performance against the project requirements. The effort conducted a successful Preliminary Design Review in June.

Planning and preparation for full initiation of the LBFD project continued during FY 2017 and it is expected that the fully-scoped project will begin in FY 2018 as part of the Agency's New Aviation Horizons initiative. In FY 2017, the project received Formulation Authorization and successfully completed Acquisition and Procurement Strategy reviews, leading to the release of a Request for Proposals in August. The announcement included a full and open competition for the design, build, and test of the LBFD aircraft, building off of information developed during the preliminary design phase. Proposals were due in October 2017, and contract award dates are anticipated for early April 2018.

In parallel with the LBFD activities, another step towards meeting the performance goal was the completion of the Level 1 milestone: Intermediate Tools for Sonic Boom Community Response. This milestone represents a key step in the development of tools that will be employed to assess the communities' response to low noise sonic boom. The research focused in two main areas. The first used laboratory studies in the development of candidate metrics to best represent human responses to hearing sonic booms indoors, and the second on the development of analytical models and tools for predicting structural response to sonic boom noise that creates indoor acoustics which in turn also induce human response.

In addition, NASA led efforts to improve the understanding of how the supersonic acoustic signature from a future quiet aircraft will interact with the atmosphere as it travels from the aircraft to the ground, and once reaching the ground how it is perceived by people, both indoors and outdoors. NASA also began planning for the LBFD aircraft tests that will collect data on human responses to supersonic overflight travel over actual communities. NASA continues to work with the international standards and regulatory communities, including the International Civil Aviation Organization and the Federal Aviation Administration, to ensure that the results of NASA's work will support the ongoing efforts to develop future certification standards for supersonic aircraft. The efforts described above are aligned with ARMD's roadmap from now through 2035 and beyond, which guides the development of innovative technologies in support of reintroducing commercial supersonic aircraft to the National Airspace System. The Thrust 2 roadmap calls for near-term demonstration of supersonic flight without disruptive sonic boom noise and delivery of scientifically valid data on community response to the U.S. and international standard and regulatory organizations. The roadmap is a living document and continues to undergo updates and assessment internal and external to NASA.

Performance Improvement Plan

NASA successfully completed the Preliminary Design Review for the LBFD aircraft, and the procurement of the LBFD aircraft is proceeding as scheduled. However, the Project Formulation Review, originally planned for FY 2017, was rescheduled for September 2018.

Performance Goal 3.2.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Yellow

Planned Future Performance (PG 3.2.2)

Year	Description
2018	3.2.2: Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.
2019	3.2.2: Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.

Data Quality Elements

Data Source
Successful completion and reports for project key decision points and lifecycle reviews. Plans and approvals for initial community response.

Verification and Validation
Measure rating reviewed and approved semi-annually and annual reviews by the Program Director and ARMD Associate Administrator (AA).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.2 Annual Performance Indicators

Annual Performance Indicator 3.2.2: AR-17-2

Year	Description
Rating	Green
2017	AR-17-2: Complete Low-Boom Flight Demonstrator (LBFD) Preliminary Design Review (PDR).
2018	AR-18-2: Award the Low-Boom Flight Demonstration (LBFD) Aircraft Design, Build, and Initial Test contract.
2019	AR-19-2: Complete the Low-Boom Flight Demonstration (LBFD) Critical Design Review (CDR).

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.

2017 Performance Results
Green

During FY 2017, NASA's Aeronautics Research Mission Directorate (ARMD) continued to support world-class research aimed at developing future aircraft that could dramatically reduce fuel burn, noise, and emissions substantially below current limits.

Boundary layer ingestion (BLI) has been recognized in recent years as a promising technology that can deliver some of the radical fuel burn and noise reductions that will be needed for future generations of aircraft. This is where the jet engines are mounted on top of the fuselage at the rear of the aircraft in a manner that enables the air flowing over the aircraft to enter the engine and join with the jet exhaust, resulting in improvement in engine efficiency. During FY 2017, NASA made significant advances in the research of BLI technology, including the following:

- NASA and its partner, United Technologies Research Center (UTRC), completed the first-ever transonic wind tunnel test of a new gas turbine engine fan design that could withstand the distorted air inflow due to BLI with minimal effect on fan performance and stability. These experiments assisted in the quantification of the BLI impact on fan performance and structural characteristics at cruise conditions.
- NASA, working with partners the Boeing Company, Massachusetts Institute of Technology, Aurora Flight Sciences, and Pratt & Whitney, developed high Mach number (M=0.78) versions of the Transonic Truss-Braced Wing (TTBW) concept and the D8 ultra-efficient aircraft. The TTBW design is slated for wind tunnel testing in FY 2019.
- System-level studies were completed showing a 5.4 percent fuel burn reduction with BLI for the D8 aircraft.

NASA is also evaluating the potential of composite fiber placement optimization for the wing skin along with topology optimization for a wings internal structure. These technologies can lead to higher aspect ratio wings, which can reduce fuel burn by decreasing aerodynamic drag. Progress was made in the design and fabrication of a 13.5 aspect ratio semi-span wing using tow-steered composite manufacturing, which will be tested in FY 2018. In addition, NASA demonstrated active flow control technologies based on sweeping jet actuators for improving aircraft performance through high Reynolds number wind tunnel tests, and evaluated a full-span configuration of a natural laminar flow model, both through testing in the National Transonic Facility. The Flexible Wing Flight Test of the X-56A research aircraft to validate performance and flying qualities of the control laws for takeoff and landing were also successfully completed.

In the area of noise reduction technologies, NASA was able to bring in and set up a Price Induction DGEN 380 geared-turbofan engine (approximately 500 pounds thrust, relevant to modern turbofan engines) to be used as a testbed to mature noise reduction, controls, and other advanced technologies in a systematic environment. The noise reduction potential of four candidate fan casing acoustic treatments in a non-traditional liner installation location were also demonstrated through tests in the W-8 Single-Stage Axial Compressor Facility at NASA's Glenn Research Center.

Enabling future ultra-efficient vertical lift capabilities is also an important aspect of Thrust 3. In FY 2017, NASA achieved significant success in demonstrating technologies to enable vertical lift configurations to fly efficiently at much faster speeds than today's configurations. NASA has designed, patented, and fabricated two innovative two-speed transmissions, the Dual-Star Idler and the Offset Compound Gear, and developed a unique facility to test scaled transmission configurations. NASA has conducted testing and analysis that has proven these types of systems would operate efficiently with low losses. NASA has also developed and

patented new hybrid metal/composite gears to reduce transmission system weight. In FY 2017, NASA was able to prove that the weight of a two-speed transmission, using the new composite technology, would be less than the current system. These findings of the weight reduction benefits for lightweight hybrid component technologies can extend beyond vertical lift to other aviation vehicles and the automotive industry.

Performance Goal 3.2.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 3.2.3)

Year	Description
2018	3.2.3: Advance airframe and engine technologies to enable the development of future generations of ultra-efficient air vehicles that minimize environmental impact.
2019	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 Quality Elements

Data Source
NASA publications (e.g., technical memoranda, contractor reports) and/or presentations and test reports.

Verification and Validation
Measure rating reviewed and approved quarterly by the Program Director and ARMD Associate Administrator (AA).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.3 Annual Performance Indicators

Annual Performance Indicator 3.2.3: AR-17-3

Year	Description
Rating	Green
2017	AR-17-3: Design, fabricate, and test an engine inlet-fan configuration that withstands the flow distortions arising from boundary layer ingestion and demonstrates vehicle-level fuel-burn benefit through minimal impact on fan performance and stability.
2018	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.
2019	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.

Annual Performance Indicator 3.2.3: AR-17-4

Year	Description
Rating	**Green**
2017	AR-17-4: Successfully complete Phase-2 Authority to Proceed (ATP) Review (i.e., Key Decision Point-D [KDP-D]), mature the down-selected tools and methodologies according to Phase-2 KDP success criteria, and fabricate key element or component-level validation test articles.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 3.2.3: AR-17-6

Year	Description
Rating	**Green**
2017	AR-17-6: Complete Critical Design Review (CDR) of the X-57 Maxwell aircraft.
2018	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).
2019	No API this fiscal year.

Annual Performance Indicator 3.2.3: AR-17-7

Year	Description
Rating	**Yellow**
2017	AR-17-7: Demonstrate advanced high-temperature engine materials for high-pressure turbine components, enabling reduced cooling and thereby lower engine fuel burn.
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.
2019	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.

Explanation of Rating

NASA completed cumulative testing under high temperature and stress conditions. Tests were conducted over at least 300 cumulative hours, at 20 kilopound per square inch (ksi) maximum stress, and at 2,700 degrees Fahrenheit max temperature. While these tests successfully accomplished the time and temperature metrics, they did not achieve the 30 ksi maximum stress necessary for a green rating. Nevertheless, demonstrations of the material's capability in a relevant geometry and environment are continuing through collaborative, cost-shared testing with Pratt & Whitney, and U.S. industry has expressed interest in acquiring the technology.

Annual Performance Indicator 3.2.3: AR-17-8

Year	Description
Rating	**Green**
2017	AR-17-8: Demonstrate a two-speed drive system that achieves a reduction in helicopter rotor revolutions per minute (RPM).
2018	AR-18-8: Demonstration of a multidisciplinary design analysis and optimization (MDAO) process for the conceptual design of vertical lift vehicles.
2019	No API this fiscal year.

Annual Performance Indicator 3.2.3: AR-19-8

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	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.

Annual Performance Indicator 3.2.3: AR-19-11

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	AR-19-11: Achieve noise reduction of at least five decibels (dB) on approach to landing during flight test operations designed for low noise.

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.

2017 Performance Results
Yellow

During FY 2017, NASA's Aeronautics Research Mission Directorate (ARMD) continued its investigations with small-core combustion technologies, as well as the development of all-electric or hybrid gas-electric propulsion systems that could enable low or nearly no carbon emission propulsion advancements.

In the area of advanced combustors, NASA and its partner, the United Technologies Research Center (UTRC), completed initial single-sector tests on an N+3 generation (N+3 is a research and development generation that is three generations beyond the current commercial transport fleet), low-emissions, fuel flexible, small core compatible combustor architecture that reduces landing and take-off (LTO) nitrogen oxide emissions by 80 percent below Committee on Aviation Environmental Protection (CAEP) 6 standards. NASA and its partners, UTRC and Pratt & Whitney, also completed a full annular combustor test with a vane pack to investigate the operability of a lean burn combustor for small core application.

In FY 2017, NASA made substantial progress in advancing technologies aimed at hybrid electric propulsion for large commercial aircraft. System-level assessments of several promising hybrid electric/turboelectric concepts, such as the Single-aisle Turboelectric AiRCraft with Aft Boundary Layer propulsion (STARC-ABL), Single-aisle Turboelectric AiRCraft-Leading-Edge Embedded Propulsion (STARC-LEED), and Parallel Electric-Gas Architecture with Synergistic Utilization Scheme (PEGASUS), were completed and showed significant reductions in fuel burn over conventional aircraft. In addition to the system-level assessments, high-efficiency and high specific power megawatt-scale powertrain components, such as the electric motors/generators and power converters, were designed. These components will be fabricated and tested in FY 2018.

NASA is also focusing on developing technologies to enable fully superconducting architectures to deliver the high power requirements for electric propulsion of large-scale commercial aircraft. In collaboration with General Electric and the Air Force Research Laboratory, NASA conducted dual-spool power extraction tests in the Glenn Research Center's Propulsion Systems Laboratory altitude test facility using a modified F110 military engine. This engine test was able to demonstrate up to 1 megawatt in total power offtake—250 kilowatts from the high spool and 750 kilowatts from the low spool—while the engine continued to generate conventional thrust and run at altitude conditions.

Performance Improvement Plan

NASA did not fully meet its performance goal due to changes to the superconducting architecture for hybrid gas-electric propulsion. However, other research efforts on alternative fuels are on track and successful. For example, NASA is moving forward with the planning, funding, and coordination of the upcoming international Emissions and Climate Impacts of Alternative Aviation Fuels (ECLIF)-2 experimental flight tests, which will be conducted in 2018. NASA is also making progress on the development of a combustor suitable for a small-core engine, which is part of the Advanced Air Vehicles Program's (AAVP's) Advanced Air Transport Technology (AATT) project. In addition, various research efforts are proceeding on schedule within the Transformative Aeronautics Concepts Program (TACP).

Performance Goal 3.2.4 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Yellow

Planned Future Performance (PG 3.2.4)

Year	Description
2018	3.2.4: Facilitate significant environmental and efficiency improvements through research on alternative jet fuel use, and on hybrid gas-electric propulsion system concepts.
2019	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 Quality Elements

Data Source
NASA publications (e.g., technical memoranda, contractor reports) and/or presentations and test reports.

Verification and Validation
Measure rating reviewed and approved quarterly by the Program Director and ARMD Associate Administrator (AA).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.4 Annual Performance Indicators

Annual Performance Indicator 3.2.4: AR-17-5

Year	Description
Rating	**Red**
2017	AR-17-5: Design and fabricate a megawatt-class fully superconducting electric machine with advanced stator design and demonstrate its capability for at least 750 kilowatt rated power.
2018	AR-18-5: Design, build, and test key ambient-temperature electric aircraft powertrain components that achieve specific performance parameters necessary for large commercial applications.
2019	AR-19-5: Design, assemble, and initiate testing of a megawatt (MW)-scale electrified aircraft powertrain.

Annual Performance Indicator 3.2.4: AR-19-12

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	AR-19-12: Demonstrate at least three times lower energy usage through replacement of general aviation internal combustion engines with batteries and electric motors.

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.

2017 Performance Results
Green

In FY 2017, NASA's Aeronautics Research Mission Directorate (ARMD) continued progress on identifying risks to provide the knowledge needed to detect, mitigate, and recover from hazardous flight conditions in real time. NASA demonstrated the effectiveness of its machine-learning algorithms that detect previously unidentified safety anomalies. Through collaboration with the MITRE Corporation and the Federal Aviation Administration (FAA), the algorithms were applied to both the Aviation Safety Information Analysis and Sharing (ASIAS) system and threaded track trajectory data. Follow-on work is planned, including maturing the algorithms into tools that MITRE and FAA analysts can use on site. NASA has also developed machine-learning algorithms to automatically identify precursors to known safety issues. For example, given a set of flights with go-arounds and some without, the algorithm was automatically able to identify unstable approach and possible overtake situations as precursors. In FY 2017, NASA demonstrated the use of this algorithm's output as a "precursor index" to provide an indication of how the probability of a given safety issue changes over time, as well as actions that reduce the likelihood of the safety issue occurring.

In May 2017, NASA completed a study on stall recovery guidance that helped to identify reasons for pilots' failure to recognize conditions that lead to aerodynamic stall and ability to respond appropriately to an unexpected stall or upset event. NASA has also completed work on training for attention management that supports a safety enhancement deliverable to the joint government and industry Commercial Aviation Safety Team.

NASA also began work on assessing and predicting the safety of the airspace through measuring appropriate real-time variables, assessing their impact on airspace state of safety, and projecting the evolution of the state of safety into the future. To that end, existing safety metrics were quantitatively described for the targeted operation, based on multivariate safety factors that contribute to operational health. These metrics were tracked and the safety margin was calculated in real-time. Several constraints were considered together to define areas of increased risk, taking into account multiple variables. An instantiation of the framework was implemented in the Testbed for Shadow-Mode Assessments using Realistic Technologies for the National Airspace System (SMART-NAS) where it was used to analyze real-time data streams from the airspace to determine current and future safety margins, probability of a violation (if any), and the locations where a violation might occur. These metrics were also extended to include select metrics associated with ground operations.

Performance Goal 3.2.5 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 3.2.5)

Year	Description
2018	3.2.5: Significantly increase the ability to anticipate and resolve potential safety issues, and to predict the health and robustness of aviation systems.
2019	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 Quality Elements

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 and Validation
Measure rating reviewed and approved quarterly by the Program Director and ARMD Associate Administrator (AA).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.5 Annual Performance Indicators

Annual Performance Indicator 3.2.5: AR-17-10

Year	Description
Rating	**Green**
2017	AR-17-10: Develop technologies and training processes that mitigate the problems and contributing factors that lead to flight crew loss of airplane state awareness.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 3.2.5: AR-18-4

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	AR-18-4: Develop initial tools for identifying, measuring, and monitoring safety margins with initial components for evolution of real-time system-wide capability.
2019	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).

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 future routine access of Unmanned Aircraft Systems (UAS) in the National Airspace System, through the development and maturation of technologies and validation of data.

2017 Performance Results
Green

Ever-increasing levels of automation and autonomy are transforming aviation. Safe integration of Unmanned Aircraft Systems (UAS), commonly called drones, into the National Airspace System (NAS) requires research in multiple areas, including communications, human-machine interfaces, sense-and-avoid, and separation assurance. NASA's aeronautical innovators addressed each of these areas during FY 2017, with a particular emphasis on developing a UAS Traffic Management (UTM) concept to handle the growing number of small drones taking to the skies.

In FY 2017, NASA successfully completed the second of four levels in a series of UTM concept demonstrations. These technology capability level (TCL) demonstrations integrate operations involving operator platforms, vehicle performance, and ground infrastructure. Each level addresses different UAS environments and incorporates the development of proposed uses, software, procedures, and policies to enable safe operation. Following a TCL1 demonstration at a single site late in 2015, NASA completed the TCL2 proof-of-concept validation at Nevada's Reno-Stead Airport in October 2016. The validation demonstrated applications that operate beyond visual line of sight of the operator in sparsely populated areas. It connected real drone-tracking systems to the UTM research platform, providing alerts for approaching drones and piloted aircraft (live or simulated), as well as providing information about weather and other hazards. In addition, the TCL2 technology was an integral part of the completed National Campaign 2 where, in May and June 2017, the six UAS National test sites flew multiple operations beyond visual line of site of the pilot in lightly populated rural environments. TCL3 and TCL4, which together will further expand the UAS operating envelope, are planned for demonstrations in calendar years 2018 and 2019. TCL3 will expand upon flight operations conducted beyond visual line of site, incorporating light integration of manned aircraft into the test environment. The planned set of tasks for the TCL3 evaluation were recently allocated to the six UAS National test sites.

In addition, NASA completed a flight test for the Airborne Collision Avoidance System for Unmanned Aircraft (ACAS-Xu). ACAS-Xu represents the next generation of detect and avoid (DAA) hardware for UAS. The test demonstrated system behavior integrated on prototype UAS avionics. ACAS-Xu provides important capabilities needed to safely integrate UAS operations into the NAS, including collision avoidance against "cooperative" and "non-cooperative" traffic aircraft (i.e., other aircraft that transmit or do not transmit their position, altitude, and velocity information, respectively) and horizontal and vertical maneuvers against multiple intruders. In addition, the advisories provided to resolve the traffic conflicts account for imperfect sensors and maneuver limitations of the UAS. The tests resulted in successful technology transfer to the Federal Aviation Administration and industry in support of the ACAS Xu Minimum Operational Performance Standards (MOPS) development.

Performance Goal 3.2.6 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 3.2.6)

Year	Description
2018	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.
2019	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 Quality Elements

Data Source
A UTM TCL research assessment and related documentation.

Verification and Validation
Measure rating reviewed and approved quarterly by the Program Director and Aeronautics Research Mission Directorate (ARMD) Associate Administrator (AA).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.2.6 Annual Performance Indicators

Annual Performance Indicator 3.2.6: AR-17-9

Year	Description
Rating	**Green**
2017	AR-17-9: Deliver the second build of an Unmanned Aircraft System Traffic Management (UTM) Technology Capability Level (TCL) demonstration to assess increased density and contingency management in low-altitude airspace.
2018	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.
2019	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.

Annual Performance Indicator 3.2.6: AR-18-10

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	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.

Strategic Objective 3.3

Inspire and engage the public in aeronautics, space, and science.

Lead Office:
Mission Support Directorate (MSD) and Office of Communications (OCOM)

Contributing Programs/Projects:
Office of Communications, Office of the Chief Scientist, Office of Diversity and Equal Opportunity

Goal Leader:
Jen Rae Wang, Associate Administrator, OCOM

Objective Overview

NASA has a long history of engaging the public in its Mission through educational and outreach activities and programs. NASA's endeavors in education and public outreach began early on, driven by the language in Section 203(a)(3) of the Space Act, "to provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof, and to enhance public understanding of, and participation in, the Nation's space program in accordance with the NASA Strategic Plan." NASA's education and outreach functions aim to inspire and engage the public and students, each playing a critical role in increasing public knowledge of NASA's work and fostering an understanding and appreciation of the value of science, technology, engineering, and mathematics (STEM), and enhancing opportunities to teach and learn.

This strategic objective includes proactive efforts to diversify the STEM pipeline to NASA internships and employment. Equal opportunity compliance and technical assistance can help to identify and report diversity and inclusion best practices among institutions receiving NASA funds that can, in turn, help increase the number of underrepresented and underserved groups in STEM fields available to apply for NASA opportunities.

The FY 2019 President's budget request proposes the termination of NASA's traditional education portfolio of domestic grants and cooperative agreements. Moving forward, a small team at NASA Headquarters will manage Agency-wide coordination of STEM engagement efforts. NASA will focus on creating unique opportunities for students and the public to contribute to NASA's work in exploration and discovery; building a diverse future STEM workforce by engaging students in authentic learning experiences with NASA's people, content, and facilities; and strengthening public understanding by enabling powerful connections to NASA's mission and work.

Strategic Objective 3.3 Data Summary

Performance Goal Ratings (3.3.1 - 3.3.5)

Fiscal Year	Total	Green	Yellow	Red	White
2017	7	7	0	0	0
2016	6	4	0	2	0
2015	6	5	1	0	0
2014	6	6	0	0	0
2013	6	4	0	0	2
2012	6	5	1	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	0	9	0	0	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 3.3.1

Enhance reach and effectiveness of programs and projects that engage the public.

2017 Performance Results
Green

NASA's Office of Communications (OCOM), in concert with the Communications Coordinating Council, developed an integrated strategic communications planning construct that engages communicators in every corner of the Agency. NASA's communications governance model, now entering its sixth year, facilitates regular assessment of strategic and operational communications efforts. Analysis and adjustments, when necessary, are accomplished through regular meetings of the council and integrated product teams (called "campaigns"). As a result, planning and decision-making for the highest priority communications projects is no longer done in isolation at the Center level, but instead elevated to the executive level at NASA Headquarters. There has been an observable enhancement in reach and public engagement, with every relevant OCOM division reporting growth and progress in key strategic areas in FY 2017.

The customer satisfaction scores for NASA's public website are among the highest in the Federal Government, and website traffic is consistently high, at about 10 million visits per month. NASA also has the most followers in the Federal Government on its Instagram, Twitter, Facebook, and Google+ social media platforms. Flagship social media accounts reach a total of 73.5 million people. OCOM has a process for approving new social media accounts that ensures both the quality and cost-effectiveness of the Agency's investments in this area. NASA continues to assess new social media tools and techniques to engage both science-attentive and non-traditional audiences. For example, in FY 2017, OCOM launched an official NASA presence on GIPHY and Pinterest, both visual platforms that present NASA imagery to new audiences. NASA increased the use of live-streaming tools to deepen its engagement with social media followers; for example, using Facebook Live to present virtual tours of unique and often off-limits facilities.

NASA's exhibits have adopted virtual reality tools, such as 3D goggles, to provide an intimate, immersive tour of the International Space Station interior, to enhance visitor experiences, and to aid in interpretation of key messages and concepts. Long lines to try out virtual reality and augmented reality systems testify to high levels of public engagement and the outreach community's ability to convey messages with a new medium. OCOM increased the use of partnerships as a public engagement tool through two recently-signed Space Act Agreements, including a 60th-anniversary performing arts celebration and a toy and book collaboration; the extension of a third Space Act Agreement with major building toymaker; and expanded activities under an existing umbrella agreement for three new virtual 360-degree field trips, which have the potential to reach up to two million students and the general public. In addition, OCOM significantly increased the accessibility of NASA's history publications through the use of eBooks. Rather than being available in a paper print run of only about 1,000 copies, eBook downloads numbered roughly 80,000 in FY 2017. The NASA History Office Twitter account has experienced a 132 percent growth in followers in FY 2017, facilitated by a collaborative anniversaries tool that has increased staff attention to social media outreach.

Performance Goal 3.3.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Yellow	Green	Green

Planned Future Performance (PG 3.3.1)

Year	Description
2018	3.3.1: Enhance reach and effectiveness of programs and projects that engage the public.
2019	3.3.1: Enhance reach and effectiveness of programs and projects that engage the public.

Data Quality Elements

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 and Validation
Review of the documentation listed under Data Sources. Rating determined by the Associate Administrator for the Office of Communications.

Data Limitations
Constrained by legal limitations on collecting information on the public. Data are sufficiently accurate for their intended use.

Performance Goal 3.3.1 Annual Performance Indicators

Annual Performance Indicator 3.3.1: AMO-17-13

Year	Description
Rating	**Green**
2017	AMO-17-13: Use current and emerging communications technologies, platforms, and methods to reach increasingly broad and diverse audiences.
2018	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.
2019	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.

Annual Performance Indicator 3.3.1: AMO-17-14

Year	Description
Rating	**Green**
2017	AMO-17-14: 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.
2018	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.
2019	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.

Annual Performance Indicator 3.3.1: AMO-17-24

Year	Description
Rating	**Green**
2017	AMO-17-24: Implement and maintain 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.
2018	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.
2019	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.

Annual Performance Indicator 3.3.1: AMO-18-17

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	No API this fiscal year.

Annual Performance Indicator 3.3.1: SMD-19-1

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	SMD-19-1: Expand Science Mission Directorate-unique assets to support learners in all 50 states.

Performance Goal 3.3.2

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

2017 Performance Results
Green

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 (EO) in programs receiving NASA funds, as well as other NASA-funded entities, including science centers and museums and research institutes. In all, NASA awards grant and cooperative or Space Act Agreement funding to some 750 such entities, with awards totaling approximately $1 billion.

In FY 2017, NASA conducted equal opportunity reviews on six recipients of NASA financial assistance, including three university STEM programs and two science museums/centers. In all, NASA has conducted 70 compliance reviews to better ensure equal opportunities in STEM education, both formal and informal. Analytics on the MissionSTEM website, the Agency's centerpiece for technical assistance on diversity and equal opportunity for its grant recipient institutions and their participants, show that the site has had five to six thousand new visitors every month during 2017.

More information is available at NASA's Office of Diversity and Equal Opportunity website.

Performance Goal 3.3.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 3.3.2)

Year	Description
2018	3.3.2: Promote equal opportunity compliance and encourage best practices among NASA grant recipient institutions.
2019	3.3.2: Promote equal opportunity compliance and encourage best practices among NASA grant recipient institutions.

Data Quality Elements

Data Source
Office of Diversity and Equal Opportunity (ODEO) Compliance Tracking System; MissionSTEM analytics.

Verification and 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 Limitations
Quantifying compliance actions in percentages is subject to some level of 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 3.3.2 Annual Performance Indicators

Annual Performance Indicator 3.1.3: AMO-17-4

Year	Description
Rating	**Green**
2017	AMO-17-4: 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.
2018	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.
2019	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.

Legacy Performance Goal*

Assure that students participating in NASA higher education investments are representative of the diversity of the Nation.

2017 Performance Results
Green

**The Office of Education is proposed for elimination in the FY 2019 President's budget request. As a result, Performance Goal 2.4.1 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 3.3. (This performance goal, 2.4.1, aligns to the* 2014 Strategic Plan *framework.)*

NASA's performance in diversity is examined across ethnicity, race, gender, and disability status. NASA Office of Education achieved this performance goal, having provided 7,770 significant, direct awards to higher education students across all institutional categories and levels in FY 2016.[10] The FY 2016 population of significant awardees exceeded the National science, technology, engineering, and mathematics (STEM) higher education enrollment percentages for the demographic categories of racially and ethnically underrepresented student participants.

NASA student participants receiving significant awards attended institutions that represent all institutional categories (Asian American and Native American Pacific Islander-Serving Institutions, American Indian and Alaskan Native-Serving Institutions, Historically Black Colleges and Universities, Predominantly White Institutions, Predominantly Black Institutions, Tribal Colleges and Universities, and Hispanic-Serving Institutions) and levels (at least two but less than four years, and four or more years), as defined by the U.S. Department of Education.

NASA Office of Education provided 32.2 percent of its significant awards to racially or ethnically underrepresented student participants, compared to 19.8 percent for the National average. NASA Office of Education provided 38.4 percent of its significant awards to women, which was slightly below the National STEM higher education degree program enrollment percentage for women reported by the U.S. Department of Education as 39.5 percent. NASA was also below the National enrollment percentage for persons with disabilities. NASA provided 2.1 percent of its significant higher education awards to persons self-reporting a disability, compared to the overall U.S. enrollment of 11 percent.

Performance Goal 2.4.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Yellow	White	Green	Green	Green	Green

Planned Future Performance (PG 2.4.1)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

[10] The NASA Office of Education rates this performance goal using data reported on the academic calendar. The FY 2017 rating is based on data from the 2015-2016 academic calendar.

Data Quality Elements

Data Source
Student profile and award records from the Office of Education Performance Measurement (OEPM) System and reports from the National Center for Education Statistics.

Verification and Validation
NASA Office of Education staff review the data collected using the OEPM System and conduct a comparative analysis with Department of Education data to determine whether goals have been met. The measure rating is reviewed and approved by the Deputy Associate Administrator for NASA Office of Education.

Data Limitations
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 Office of Education uses prior year data (e.g., in FY 2017, NASA Office of Education reports on FY 2016 data) to meet performance reporting requirements. Data are sufficiently accurate for their intended use.

Performance Goal 2.4.1 Annual Performance Indicators

Annual Performance Indicator 2.4.1: ED-17-1

Year	Description
Rating	**Green**
2017	ED-17-1: 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 its or exceed the National enrolled 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.
2018	No API this fiscal year.
2019	No API this fiscal year.

Legacy Performance Goal*

Continue to support STEM educators through the delivery of NASA education content and engagement in educator professional development opportunities.

2017 Performance Results
Green

**The Office of Education is proposed for elimination in the FY 2019 President's budget request. As a result, Performance Goal 2.4.2 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 3.3. (This performance goal, 2.4.2, aligns to the* 2014 Strategic Plan *framework.)*

Through NASA Office of Education, 40,010 educators participated in NASA educator professional development activities through Face-to-Face Institutes, online educator professional development, community-requested educator professional development, and partner-delivered educator professional development. The educator professional development participants included 31,372 in-service K-12 educators, 3,453 informal educators, 1,566 higher education faculty, and 3,619 preservice educators. Additionally, 36,597 educators participated in NASA STEM engagement outreach activities.[11]

Performance Goal 2.4.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	White	Green	Green	Red	Green

Planned Future Performance (PG 2.4.2)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Project activity data from the Office of Education Performance Measurement (OEPM) System.

Verification and Validation
NASA Office of Education staff review the data collected using the OEPM System and conduct a comparative analysis with Department of Education data to determine whether goals have been met. The measure rating is reviewed and approved by the Deputy Associate Administrator for NASA Office of Education.

Data Limitations
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 Office of Education uses prior year data (e.g., in FY 2017, NASA Office of Education reports on FY 2016 data) to meet performance reporting requirements. Data are sufficiently accurate for their intended use.

[11] The NASA Office of Education rates this performance goal using data reported on the academic calendar. The FY 2017 rating is based on data from the 2015-2016 academic calendar.

Performance Goal 2.4.2 Annual Performance Indicators

Annual Performance Indicator 2.4.2: ED-17-2

Year	Description
Rating	**Green**
2017	ED-17-2: Engage with at least 10,000 educators in NASA educator professional development through face-to-face, online, partner-delivered, and community-requested activities.
2018	No API this fiscal year.
2019	No API this fiscal year.

Legacy Performance Goal*

Continue to provide opportunities for learners to engage in STEM education through NASA-unique content provided to informal education institutions designed to inspire and educate the public.

2017 Performance Results
Green

**The Office of Education is proposed for elimination in the FY 2019 President's budget request. As a result, Performance Goal 2.4.4 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 3.3. (This performance goal, 2.4.4, aligns to the* 2014 Strategic Plan *framework.)*

NASA Office of Education achieved this performance goal by providing NASA-unique content through partnerships with informal education institutions. NASA Office of Education supports a diverse portfolio of programs that enhance education efforts on space exploration, aeronautics, space science, Earth science, and microgravity research.

These partnerships, maintained through the NASA Museum Alliance and other NASA Office of Education activities, result in strategic collaboration between science, technology, engineering, and mathematics (STEM) formal and informal education providers. During FY 2017, they included science centers, planetariums, museums, aquariums, zoos, nature centers, parks and observatories, Federal and non-Federal NASA Visitor Centers and affiliates, and Challenger Centers and youth-serving organizations. A total of 823 informal education institutions, including youth-serving organizations, collaborated with NASA Office of Education to deliver NASA-unique STEM content in all 50 states, the District of Columbia, and Puerto Rico.

Performance Goal 2.4.4 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 2.4.4)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Project activity and affiliate/partner network data from the Office of Education Performance Measurement (OEPM) System.

Verification and Validation
NASA Office of Education staff review the data collected using the OEPM System and conduct a comparative analysis with Department of Education data to determine whether goals have been met. The measure rating is reviewed and approved by the Deputy Associate Administrator for NASA Office of Education.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.4.4 Annual Performance Indicators

Annual Performance Indicator 2.4.4: ED-17-4

Year	Description
Rating	**Green**
2017	ED-17-4: Support informal education institutions, including youth-serving organizations, to use NASA-unique content in no fewer than 40 states, U.S. Territories and/or the District of Columbia.
2018	No API this fiscal year.
2019	No API this fiscal year.

Legacy Performance Goal*

Continue to provide opportunities for learners to engage in STEM education engagement activities that capitalize on NASA-unique assets and content.

2017 Performance Results
Green

**The Office of Education is proposed for elimination in the FY 2019 President's budget request. As a result, Performance Goal 2.4.5 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 3.3. (This performance goal, 2.4.5, aligns to the* 2014 Strategic Plan *framework.)*

NASA Office of Education achieved this performance goal by exceeding the FY 2016[12] target number of students who participate in science, technology, engineering, and mathematics (STEM) engagement activities. Through NASA Office of Education, 184,219 students participated in authentic STEM experiences that engaged learners directly or indirectly with practitioners and in developmentally-appropriate practices from the STEM disciplines that promote real-world understanding. This figure includes 66,862 elementary students, 56,282 middle school students, 32,799 high school students, and 28,276 higher education students. In addition to the participants in authentic STEM experience, 445,139 elementary, secondary, and higher education students participated in other NASA Office of Education STEM engagement activities.

Performance Goal 2.4.5 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Red	Green

Planned Future Performance (PG 2.4.5)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Project activity data from the Office of Education Performance Measurement (OEPM) System.

Verification and Validation
NASA Office of Education staff review the data collected using the OEPM System and conduct a comparative analysis with Department of Education data to determine whether goals have been met. The measure rating is reviewed and approved by the Deputy Associate Administrator for NASA Office of Education.

Data Limitations
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 Office of Education uses prior year data (e.g., in FY 2017, NASA Office of Education reports on FY 2016 data) to meet performance reporting requirements. Data are sufficiently accurate for their intended use.

[12] The NASA Office of Education rates this performance goal using data reported on the academic calendar. The FY 2017 rating is based on data from the 2015-2016 academic calendar.

Performance Goal 2.4.5 Annual Performance Indicators

Annual Performance Indicator 2.4.5: ED-17-5

Year	Description
Rating	**Green**
2017	ED-17-5: Provide NASA STEM engagement to at least 50,000 elementary, secondary, and higher education students through authentic STEM experiences.
2018	No API this fiscal year.
2019	No API this fiscal year.

Legacy Performance Goal*

Ensure that grantees and cooperative agreement awardees conduct independent evaluations, providing evidence for the effectiveness of NASA STEM education investments.

2017 Performance Results
Green

**The Office of Education is proposed for elimination in the FY 2019 President's budget request. As a result, Performance Goal 2.4.6 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 3.3. (This performance goal, 2.4.6, aligns to the* 2014 Strategic Plan *framework.)*

NASA Office of Education has made progress towards increasing evaluation use among NASA Office of Education grantees and cooperative agreement awardees to support evidence-based practices. During FY 2016, 42 percent of NASA Office of Education grantees and cooperative agreement awardees who received grants or awards of $400,000 or higher conducted independent evaluations of their activities, exceeding the fiscal year's target of 30 percent.

Performance Goal 2.4.6 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	Green

Planned Future Performance (PG 2.4.6)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Project activity data from the Office of Education Performance Measurement (OEPM) System.

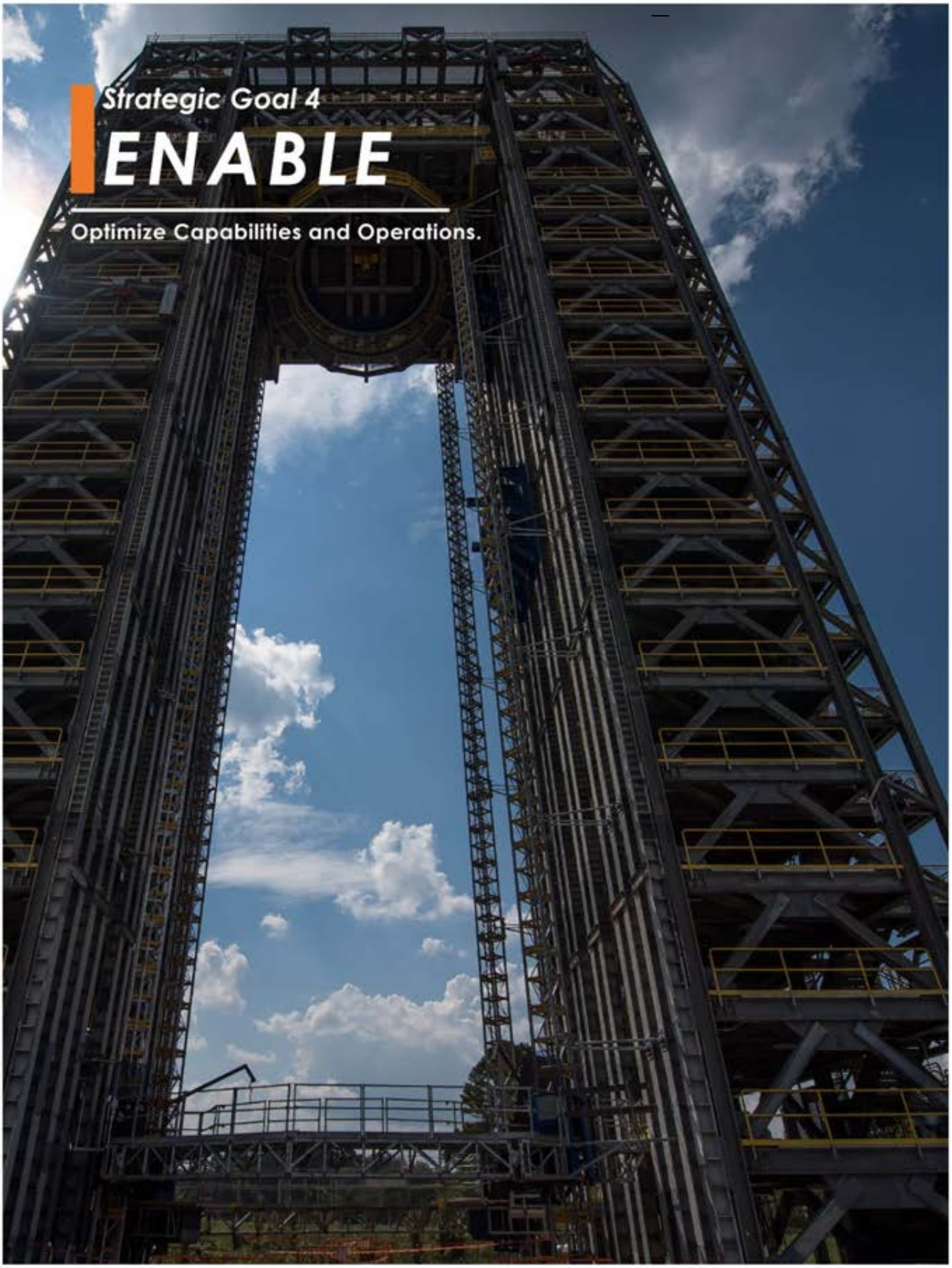
Verification and Validation
NASA Office of Education staff review the data collected using the OEPM System and conduct a comparative analysis with Department of Education data to determine whether goals have been met. The measure rating is reviewed and approved by the Deputy Associate Administrator for NASA Office of Education.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 2.4.6 Annual Performance Indicators

Annual Performance Indicator 2.4.6: ED-17-3

Year	Description
Rating	**Green**
2017	Ensure that at least 30 percent of grantees and cooperative agreement awardees conduct independent evaluations and report to NASA on their evaluation activities.
2018	No API this fiscal year.
2019	No API this fiscal year.



Strategic Goal 4

ENABLE

Optimize Capabilities and Operations.

Summary of Performance for Strategic Goal 4

Strategic Goal 4 includes a hybrid of management and strategic objectives led by the Human Exploration and Operations Mission Directorate (HEOMD), and numerous Agency mission support offices and organizations.

Performance Goal Ratings by Strategic Objective for FY 2017

Lead	Strategic Objective	Performance Goals				
		Total	Green	Yellow	Red	White
MSD	4.1	3	3	0	0	0
HEOMD	4.2	8	7	1	0	0
OCE / OCHMO / OSMA	4.3	2	2	0	0	0
MSD / OHCM	4.4	2	2	0	0	0
Principal Advisor for Enterprise Protection / OCIO	4.5	5	4	1	0	0
MSD	4.6	3	2	0	1	0
Total		**23**	**20**	**2**	**1**	**0**
Summary			**87%**	**9%**	**4%**	**0%**

Annual Performance Indicator Ratings by Strategic Objective for FY 2017

Lead	Strategic Objective	Annual Performance Indicators				
		Total	Green	Yellow	Red	White
MSD	4.1	5	5	0	0	0
HEOMD	4.2	9	8	1	0	0
OCE / OCHMO / OSMA	4.3	5	5	0	0	0
MSD / OHCM	4.4	3	3	0	0	0
Principal Advisor for Enterprise Protection / OCIO	4.5	8	3	5	0	0
MSD	4.6	5	4	0	1	0
Total		**35**	**28**	**6**	**1**	**0**
Summary			**80%**	**17%**	**3%**	**0%**

Strategic Objective 4.1

Engage in partnership strategies.

Lead Office:
Mission Support Directorate (MSD)

Goal Leader:
Daniel Tenney, Associate Administrator, MSD

Contributing Programs/Projects:
Office of Procurement, Partnerships Office, Office of International and Interagency Relations, and Office of Small Business Programs

Objective Overview:
NASA identifies, establishes, and maintains a diverse set of domestic and international partnerships to enable collaborations of mutual benefit to NASA and other Government agencies, U.S. industry, academia, nonprofit organizations, state and local governments, and international entities that contribute to the Agency's strategic objectives and develop capabilities to achieve NASA's Mission.

NASA partners with other Federal departments and agencies, the U.S. private sector, non-profit organizations, universities, and foreign space agencies to coordinate, develop, and implement mutually beneficial cooperative space working groups, programs, projects, missions, and ground-based research activities that support the NASA's *2018 Strategic Plan*. These partnerships are instrumental in supporting the strategic goals and strategic objectives in NASA's *2018 Strategic Plan*. Such partnerships provide access to unique capabilities and expertise, increase mission flight opportunities, and enhance the scientific return of the Agency's Mission.

Strategic Objective 4.1 Data Summary

Performance Goal Ratings (4.1.1 – 4.1.5)

Fiscal Year	Total	Green	Yellow	Red	White
2017	3	3	0	0	0
2016	3	2	1	0	0
2015	3	3	0	0	0
2014	3	3	0	0	0
2013	2	2	0	0	0
2012	2	2	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	5	5	0	0	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 4.1.1

Does not trend until FY 2018.

2017 Performance Results
N/A

This is a new performance goal in FY 2018.

Performance Goal 4.1.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 4.1.1)

Year	Description
2018	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.
2019	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.*

* NASA will revise or replace this performance goal with a more outcome-oriented measure in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Data Quality Elements

Data Source
NASA Headquarters Mission Directorate Reviews; information from the Partnership Agreement Maker (PAM) database; and Partnership Council meetings and briefings.

Verification and Validation
Review of the documentation listed under Data Sources; Partnership Council review of significant partnership activities; and compliance with NASA Policy Directive 1050.I1 and NASA Advisory Implementing Instructions (NAII) 1050-1, 1050-2 and 1050-3.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.1.1 Annual Performance Indicators

Annual Performance Indicator 4.1.1: AMO-18-30

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	AMO-18-30: Negotiate and sign at least 300 new partnership agreements with domestic, non-governmental parties.
2019	AMO-19-5: Negotiate and sign at least 300 new partnership agreements with domestic, non-governmental parties.*

* NASA will revise or replace this annual performance indicator with a more outcome-oriented measure in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Annual Performance Indicator 4.1.1: AMO-17-7

Year	Description
Rating	**Green**
2017	AMO-17-7: Negotiate and conclude international and interagency agreements with foreign and domestic partners in support of NASA missions.
2018	AMO-18-11: Negotiate and conclude at least 80 international and interagency agreements with foreign and domestic partners in support of NASA missions.
2019	AMO-19-6: Negotiate and conclude at least 80 international and interagency agreements with foreign and domestic partners in support of NASA missions.*

* NASA will revise or replace this annual performance indicator with a more outcome-oriented measure in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Performance Goal 4.1.2

Achieve savings for the Agency through acquisition reforms.

2017 Performance Results
Green

NASA met its performance goal through the effective use of strategic sourcing strategies, both at the Federal and Agency level, as well as through increased contract efficiencies and reduced transaction costs in NASA procurements. Of the 10 strategic sourcing initiatives NASA identified for FY 2017, all 10, or 100 percent, achieved cost avoidance. Some significant examples are summarized below:

- Solutions for Enterprise-Wide Procurement (SEWP) V is a multi-award, government-wide acquisition contract that negotiates cost avoidance through leveraged purchases, reduced fees for utilization, and decreased price per unit (compared to current, higher market prices). For FY 2017, the total negotiated cost avoidance combined for SEWP V was approximately $5.3 million, an amount that reflects an adjustment to account for the administrative cost of running the program.
- Office Supplies Third Generation (OS3) is a purchasing channel solution that helps Federal customers achieve savings on their office supply purchases, while also supporting the Nation's small businesses. NASA increased its use of OS3 by approximately 62 percent in FY 2016 and an additional 3 percent in FY 2017, resulting in cost avoidance of roughly $45 thousand in FY 2017.
- The Enterprise License Management Team (ELMT) is an Agency-based, strategic sourcing effort to consolidate software licenses across the Agency. ELMT continues to identify and add additional software to its inventory, which increases NASA's buying power by lowering the price per unit. ELMT achieved an estimated cost avoidance of $79.2 million in FY 2017.
- The 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 cost avoidance of an estimated $19.2 million in FY 2017 by providing business at a reduced cost over previous prices paid.
- NASA's Information Technology (IT) Infrastructure Integration Program (I3P) is transforming NASA's IT infrastructure services from a Center-based model to an enterprise-based management and provisioning model. I3P achieved an estimated $64.2 million in cost avoidance in FY 2017, representing negotiated cost and fee avoidance for four of the primary contracts that comprise the I3P activities.

NASA also achieved savings through increased contract efficiencies and reduced transaction costs in its procurements. NASA achieved this through reduced contract lead times, using less complex evaluation procedures, reducing the number task orders, consolidating software licenses, and reducing the number of award-fee contracts and incremental funding or deobligation actions. Of the eight contract efficiency initiatives NASA identified for FY 2017, seven, or 87.5 percent, were effective in reducing cost. A couple significant examples are summarized below:

- NASA exercised the option on a reverse auctioning contract with FedBid, Inc., resulting in approximately $22 thousand of cost avoidance. This equates to roughly a 25 percent savings on the transactions.
- The NASA Shared Services Center (NSSC) consolidates and standardizes over 50 business, technical, and administrative services to customers from across the Agency. By redirecting critical resources back to core missions, the NSSC allows the remainder of the Agency to concentrate on performing core engineering services and scientific research. The NSSC transactional savings resulting from the consolidation of common transactional services achieved an estimated cost avoidance of $6.26 million in FY 2017.

More information is available at the Office of Procurement website.

Performance Goal 4.1.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.1.2)

Year	Description
2018	4.1.2: Achieve savings for the Agency through acquisition reforms.
2019	4.1.2: Achieve savings for the Agency through acquisition reforms.

Data Quality Elements

Data Source
NASA Strategic Sourcing Plan, Master Buy Plan Database, and Federal Procurement Data System.

Verification and Validation
Review compliance with the Office of Management and Budget Strategic Sourcing Policy, NASA Policy Directive 1000.5B, Federal Acquisition Regulation (FAR), and the NASA FAR Supplement.

Data Limitations
Contract data availability from the Federal Procurement Data System and Federal Strategic Sourcing Initiative data collection systems lags the reporting cycle. Data are sufficiently accurate for their intended use.

Performance Goal 4.1.2 Annual Performance Indicators

Annual Performance Indicator 4.1.2: AMO-17-8

Year	Description
Rating	Green
2017	AMO-17-8: Achieve savings through effective use of both Federal-level and Agency-level strategic sourcing approaches.
2018	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.
2019	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.

Annual Performance Indicator 4.1.2: AMO-17-9

Year	Description
Rating	Green
2017	AMO-17-9: Achieve savings through increased contract efficiencies and reduced transaction costs in NASA procurements.
2018	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.
2019	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.

Performance Goal 4.1.3

Does not trend until FY 2018.

2017 Performance Results
N/A

This is a new performance goal in FY 2018.

Performance Goal 4.1.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 4.1.3)

Year	Description
2018	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.
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.

Data Quality Elements

Data Source
NASA's Office of Small Business Programs (OSBP) website; NASA Vendor Database; press releases; and NASA-internal documentation.

Verification and Validation
Review of the documentation listed under Data Sources. Final rating is determined by the Associate Administrator of OSBP.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.1.3 Annual Performance Indicators

Annual Performance Indicator 4.1.3: AMO-18-32

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	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.

Annual Performance Indicator 4.1.3: AMO-18-33

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	AMO-18-33: Implement a strategic training plan to promote the NASA Small Business Program.
2019	No API this fiscal year.

Annual Performance Indicator 4.1.3: AMO-19-12

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	AMO-19-12: Implement a set of pre-award procurement activities designed to increase opportunities for small businesses.

Legacy Performance Goal*

Manage coordination of NASA's international and interagency activities in conjunction with the NASA mission directorates.

2017 Performance Results
Green

**Performance Goal 3.1.5 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 4.1. (This performance goal, 3.1.5, aligns to the 2014 strategic plan framework.)*

During FY 2017, NASA's Office of International and Interagency Relations (OIIR) fully supported NASA's international and interagency activities. OIIR provides executive leadership and coordination for all of NASA's international activities and partnerships, and for policy interactions between NASA and other Executive Branch offices and agencies. 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 also directs NASA's international relations; negotiates cooperative and reimbursable agreements with foreign space partners; provides management oversight and staff support of NASA's advisory committees, commissions, and panels; and manages the NASA Export Control Program and foreign travel.

In FY 2017, OIIR produced 12 monthly reports on the management of 820 active international agreements with 131 countries and the management of 950 interagency agreements with 50 agencies. OIIR concluded 82 new agreements with 27 countries and international organizations, and had an additional 109 agreements in development.

In addition, OIIR continued implementing an Agency-wide export control training program. This training includes export control regulations affecting NASA programs and best practices for facilitating execution of international programs. OIIR held the week-long annual NASA Export Control Program Review at the Kennedy Space Center in February through March 2017. NASA posted multiple online learning modules of export control training to its internal career training and development website. In addition, the Agency conducted 4 export control training sessions at Headquarters, and Center Export Control Staff conducted an additional 34 export control sessions at their individual Centers, ensuring all 10 Centers had export control training.

Performance Goal 3.1.5 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 2.4.6)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
NASA Headquarters Mission Directorate Reviews.

Verification and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.1.5 Annual Performance Indicators

Annual Performance Indicator 3.1.5: AMO-17-6

Year	Description
Rating	Green
2017	AMO-17-6: Implement the Agency-wide export control training program.
2018	No API this fiscal year.
2019	No API this fiscal year.

Legacy Performance Goal*

Manage coordination of advisory committees' (NASA Advisory Council and Aerospace Safety Advisory Panel) recommendations to the NASA Administrator.

2017 Performance Results
Green

**Performance Goal 3.1.9 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 4.1. (This performance goal, 3.1.9, aligns to the 2014 strategic plan framework.)*

In addition to its work with international and interagency partners, the Office of International and Interagency Relations (OIIR) supports NASA's Federal advisory committees and the Agency's legal compliance with the Federal Advisory Committee Act (FACA). This includes direct management of NASA's two most senior advisory committees that report to the NASA Administrator, the NASA Advisory Council (NAC) and the NASA Aerospace Safety Advisory Panel (ASAP), as well as management oversight for nine other NASA Federal advisory committees, five of which were formally chartered by OIIR during FY 2017. During FY 2017, OIIR coordinated two incoming NAC recommendations and four incoming ASAP recommendations to the NASA Administrator. OIIR directly planned and executed 10 NAC meetings (3 NAC public meetings and 7 site visits) and 13 ASAP meetings (4 quarterly meetings and 9 insight site visits). OIIR also coordinated the development, publication and public rollout of the *ASAP Annual Report for 2016*, which was delivered to the Agency leadership and the U.S. Congress in January 2017.

Performance Goal 3.1.9 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Yellow	Green

Planned Future Performance (PG 3.1.9)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
Aerospace Safety Advisory Panel Annual Report to Congress.

Verification and Validation
Review compliance with NASA Policy Directive 1150.11A.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.1.9 Annual Performance Indicators

Annual Performance Indicator 3.1.9: AMO-17-15

Year	Description
Rating	**Green**
2017	AMO-17-15: Provide NASA responses to advisory committees' recommendations made formally to the NASA Administrator.
2018	No API this fiscal year.
2019	No API this fiscal year.

Strategic Objective 4.2

Enable space access and services.

Lead Office:
Human Explorations and Operations Mission Directorate (HEOMD)

Goal Leader:
Mark Geyer, Acting Deputy Associate Administrator, Technical, HEOMD

Contributing Programs/Projects:
Launch Services, Crew and Cargo, Commercial Crew, Rocket Propulsion Test, Space Communications and Navigation, Strategic Capabilities Asset Program (and Space Environments Testing Management Office)

Objective Overview

NASA uses private and government capabilities to deliver people, payloads, and data to and from space. Two examples of such private capabilities are the Commercial Crew Program and the Launch Services Program. These programs implement strategic investment decisions to sustain and enable U.S. commercial industry and to provide transportation of crew, cargo, and key scientific payloads to their destinations in space.

The Space Communications and Navigation (SCaN) program manages and directs the ground-based facilities and services provided by the Deep Space Network (DSN), Near Earth Network (NEN), and Space Network (SN). SCaN supports three reliable communications networks with data transmissions between space missions and Earth. NASA's other technical capabilities in the Rocket Propulsion Test program, Strategic Capabilities Asset Program, and Space Environments Testing Management Office support commercial industries by providing specialized facilities to test and evaluate items to mitigate risk and optimize engineering designs. All of these capabilities are critical to enabling space missions that allow NASA and its partners to discover new science, explore the solar system, and develop transformative technologies and research that will drive the national economy.

Strategic Objective 4.2 Data Summary

Performance Goal Ratings (4.2.1 - 4.2.8)

Fiscal Year	Total	Green	Yellow	Red	White
2017	8	7	1	0	0
2016	8	8	0	0	0
2015	8	7	1	0	0
2014	8	8	0	0	0
2013	6	6	0	0	0
2012	6	6	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	9	8	1	0	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 4.2.1

Provide cargo transportation to support on-orbit crew members and utilization.

2017 Performance Results
Green

During FY 2017, NASA continued to provide cargo transportation to the International Space Station (ISS), supporting on-orbit crew operations through agreements with foreign partners and U.S. commercial providers. Cargo transportation was provided by the Russian Federation's Progress expendable cargo spacecraft, the Japan Aerospace Exploration Agency's (JAXA's) H-II Transfer Vehicle (HTV) automated cargo spacecraft, Orbital ATK's Cygnus vehicle, and the Space Exploration Technologies Corporation's (SpaceX's) Dragon spacecraft.

U.S. commercial providers completed five Commercial Resupply Services (CRS) flights delivering cargo to support on-orbit crew members:

- Orbital ATK CRS-5's Cygnus vehicle launched on an Antares 230 on October 17, 2016, from Wallops Flight Facility, VA.
- SpaceX CRS-10's Dragon vehicle launched on a Falcon 9 on February 19, 2017, from Kennedy Space Center (KSC), FL.
- Orbital ATK CRS-7's Cygnus vehicle launched on an Atlas V on April 18, 2017, from Cape Canaveral Air Force Station, FL.
- SpaceX CRS-11's Dragon vehicle launched on a Falcon 9 on June 3, 2017, from KSC.
- SpaceX CRS-12's Dragon vehicle launched on a Falcon 9 on August 14, 2017, from KSC.

Performance Goal 4.2.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Yellow	Green	Green

Planned Future Performance (PG 4.2.1)

Year	Description
2018	4.2.1: Provide cargo transportation to support on-orbit crew members and utilization.
2019	4.2.1: Provide cargo transportation to support on-orbit crew members and utilization.

Data Quality Elements

Data Source
Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC) and the ISS Program Quarterly Reviews.

Verification and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.1 Annual Performance Indicators

Annual Performance Indicator 4.2.1: ISS-17-8

Year	Description
Rating	**Green**
2017	ISS-17-8: Complete at least three flights, delivering research and logistics hardware to the ISS, by U.S.-developed cargo delivery systems.
2018	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.
2019	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.

Performance Goal 4.2.2

Facilitate the development of and certify U.S. industry-based crew transportation systems while maintaining competition. (Agency Priority Goal)

2017 Performance Results
Yellow

NASA made progress towards this agency priority goal (APG) in FY 2017, but did not complete the APG as planned. During FY 2017, the Boeing Company (Boeing) and Space Explorations Technologies Corporation (SpaceX) both made significant technical and programmatic progress maturing their respective industry-based crew transportation systems; however, neither completed its Design Certification Review, which was NASA's FY 2016-17 APG.

The NASA Commercial Crew Program is facilitating the development of U.S. commercial crew space transportation capabilities, with the goal of achieving safe, reliable, and cost-effective access to and from low Earth orbit and the International Space Station (ISS). Enabling a U.S. industry-based capability can facilitate the development of a commercial market, providing new high-technology jobs and reducing the cost of human access to space. NASA is working with two commercial partners, Boeing and SpaceX, to complete development and NASA certification for human space transportation systems capable of carrying people into orbit.

During FY 2017, NASA and its commercial partners continued to close out alternate standards, hazard reports, and known variances. NASA is tracking burn down of Verification Closure Notices as its industry partners progress toward demonstration flights and certification. Both partners are currently manufacturing qualification and flight hardware and have begun qualification and acceptance test activities.

In addition, Boeing completed the base test series for the Service Module's structural test article. An structural test article is hardware built to replicate conditions and behaviors of flight-ready versions for ground testing. Boilerplate-3 was delivered to NASA for future water rescue training. In addition, Boeing completed a crew emergency egress system demonstration. SpaceX completed integration of the pressurized section and service section for its Demonstration Mission 1 spacecraft, which will undertake its first, un-crewed flight test to the ISS. SpaceX also began structural qualification testing of its Dragon spacecraft. In addition, SpaceX supported testing by the U.S. Air Force of the Dragon Recovery Trainer, a full-scale practice version of the company's Dragon spacecraft.

Performance Improvement Plan

Both of NASA's industry partners continue to make progress in closing out their designs and moving into verification and validation activities. NASA is working with its partners to determine where schedule adjustments may be necessary as the providers work toward full certification of their respective crew transportation systems.

Performance Goal 4.2.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Yellow

Planned Future Performance (PG 4.2.2)

Year	Description
2018	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)
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)

Data Quality Elements

Data Source
Email(s) and press releases indicating industry partners continue to make progress maturing their transportation system technical and certification/verification efforts.

Verification and Validation
Review by NASA's Program Management Council and the Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC).

Data Limitations
Materials provided by NASA's industry partners may include company-proprietary information. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.2 Annual Performance Indicators

Annual Performance Indicator 4.2.2: CS-17-1

Year	Description
Rating	**Yellow**
2017	CS-17-1: Continue monitoring partner milestone progress toward identifying and closing certification products, in alignment with negotiated contract milestones.
2018	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.
2019	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.

Explanation of Rating

As stated above, NASA will continue to work with its industry partners toward full certification of their respective crew transportation systems.

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 transportation capabilities.

2017 Performance Results
Green

NASA is working with the American aerospace industry as multiple companies design and develop commercial spaceflight capabilities for low Earth orbit and beyond. By supporting these development efforts, NASA is laying the foundation for future commercial transportation capabilities that could become available to NASA, other government agencies, and industry customers.

NASA is continuing to invest financial and technical resources within the private sector. NASA's commercial partners continue to make progress completing planned milestones. For example, the Sierra Nevada Corporation continues preparing its Dream Chaser engineering test article to support its approach and landing test, planned for October 2017. United Launch Alliance (ULA), Blue Origin, and Space Explorations Technologies Corporation (SpaceX) conducted multiple technical meetings with NASA personnel as they continued the development of their respective commercial space capabilities. Final Frontier Design completed its commercial spacesuit, planned for testing in microgravity in early FY 2018. Orbital ATK is manufacturing its flight Mission Extension Vehicle (MEV) in preparation for its initial flight.

Performance Goal 4.2.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.2.3)

Year	Description
2018	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.
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.

Data Quality Elements

Data Source
Email(s) and press releases indicating industry partners continue to make progress maturing their transportation system technical and certification/verification efforts.

Verification and Validation
Review by NASA's Program Management Council and the Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC).

Data Limitations
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 Annual Performance Indicators

Annual Performance Indicator 4.2.3: CS-17-2

Year	Description
Rating	**Green**
2017	CS-17-2: Continue monitoring partner milestone progress based on agreement content.
2018	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.
2019	CS-19-2: Continue monitoring partner milestone progress based on agreement content, including the launch of Orbital ATK's first Mission Extension Vehicle (MEV).

Performance Goal 4.2.4

Review the current state of the NASA test capabilities, known test requirements and test requests, and revise the Master Plan as needed.

2017 Performance Results
Green

NASA's Rocket Propulsion Test (RPT) Program 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 prioritizes its limited resources to sustain its core test capabilities and meet customer test requirements. In addition, the RPT program is NASA's representative on the National Rocket Propulsion Test Alliance (NRPTA), which was established between NASA and the Department of Defense in 1998. The NRPTA helps shape the Federal Government's rocket propulsion test capabilities to better meet National test needs through intra- and interagency cooperation, and recommends solutions to provide the best overall value to taxpayers.

The RPT program continually monitors the state of its test capabilities, known test requirements, and test requests. NASA uses weekly Rocket Propulsion Test Management Board (RPTMB) teleconferences and semi-annual Program Manager Reviews to monitor the condition and operational state of all facilities, and work solutions as needed. The RPTMB also tracks current test activities, requirements for upcoming tests, and requests for future testing. The Master Plan is current in relation to the Program Commitment Agreement and the current state of the program's infrastructure. In FY 2017, the RPT program performed 586 tests totaling 18,423 seconds, while maintaining 98.8 percent test stand availability.

Performance Goal 4.2.4 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.2.4)

Year	Description
2018	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.
2019	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 Quality Elements

Data Source
RPT staff presentations at quarterly Directorate Program Management Council (DPMC) and Program Management Review (PMR) meetings.

Verification and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.4 Annual Performance Indicators

Annual Performance Indicator 4.2.4: SFS-17-2

Year	Description
Rating	**Green**
2017	SFS-17-2: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.
2018	SFS-18-2: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.
2019	SFS-19-2: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.

Performance Goal 4.2.5

Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.

2017 Performance Results
Green

NASA's Launch Services Program (LSP) is responsible for the acquisition and management of commercial, expendable launch vehicle missions. LSP provides safe, reliable, cost-effective, and on-schedule launch services to 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 completed all FY 2017 objectives for all NASA-managed expendable launches as defined under this performance goal. LSP sustained a 100 percent success rate for FY 2017 with the successful launch of the Geostationary Operational Environmental Satellite (GOES)-R aboard an Atlas V on November 19, 2016; the Cyclone Global Navigation Satellite System (CYGNSS) aboard a Pegasus-XL on December 15, 2016; and the Tracking and Data Relay Satellite System (TDRS)-M aboard an Atlas V on August 18, 2017. All three missions launched from Cape Canaveral Air Force Station (CCAFS) in Florida.

In addition, LSP successfully completed all acquisitions scheduled for award in FY 2017 to date. Each acquisition was awarded on-time and met customer requirements:

- The Surface Water and Ocean Topography (SWOT) launch service was awarded to Space Exploration Technologies Corporation (SpaceX) of Hawthorne, CA. SWOT will launch in April 2021 aboard a Falcon 9 Full Thrust rocket from Space Launch Complex (SLC) 41 at CCAFS.
- The Joint Polar Satellite System (JPSS)-2 launch service was awarded to United Launch Services LLC (ULS) of Centennial, CO. JPSS-2 will launch in July 2021 aboard an Atlas V 401 rocket from SLC 3E at Vandenberg Air Force Base in California.

LSP also worked on launch service task order acquisitions for Sentinel-6A and Landsat-9, with award anticipated in early FY 2018.

Performance Goal 4.2.5 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.2.5)

Year	Description
2018	4.2.5: Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.
2019	4.2.5: Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.

Data Quality Elements

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 and Validation
Review of the documentation listed under Data Sources by the Human Exploration and Operations Mission Directorate Launch Services Office, Director; and LSP Program Planning Office.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.5 Annual Performance Indicators

Annual Performance Indicator 4.2.5: SFS-17-3

Year	Description
Rating	Green
2017	SFS-17-3: Sustain a 100 percent success rate with the successful launch of NASA-managed expendable launches as identified on the Launch Services Flight Planning Board manifest.
2018	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.
2019	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.

Annual Performance Indicator 4.2.5: SFS-17-4

Year	Description
Rating	Green
2017	SFS-17-4: Complete acquisitions on time for NASA-managed expendable launches.
2018	SFS-18-4: Complete acquisitions on time for NASA-managed expendable launches.
2019	SFS-19-4: 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.

2017 Performance Results
Green

The NASA Space Communications and Navigation (SCaN) program is responsible for the Agency-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 for three networks, including the Near Earth Network (NEN), Space Network (SN), and Deep Space Network (DSN), which span the globe and support over 70 space missions. The SN consists of a constellation of geosynchronous satellites named the Tracking Data Relay Satellite (TDRS) system, and the associated ground systems and facilities that operate the space network relay system between satellites in low Earth orbit.

The SN maintains near-continuous communications with the International Space Station (ISS), the Hubble Space Telescope, and other satellites below geosynchronous Earth orbit, and supports resupply missions to the ISS. SCaN's three networks operate 24 hours a day, seven days a week, 365 days per year. During FY 2017, the NEN, SN, and DSN each exceeded their requirement of 95 percent delivery of network services, achieving an actual service delivery of over 99 percent.

On August 18, 2017, NASA successfully launched the TDRS-M spacecraft. TDRS-M is the final third-generation satellite to join the TDRS fleet. The replenishment of the TDRS fleet will help ensure that NASA's SN is able to continue to provide around-the-clock, high throughput communications services to NASA's missions, including the ISS. TDRS-M will enter into full operations in FY 2018.

Performance Goal 4.2.6 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.2.6)

Year	Description
2018	4.2.6: Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success.
2019	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 Quality Elements

Data Source
NASA-internal presentation charts and link(s) to external press releases.

Verification and Validation
Review of the documentation listed under Data Sources by the Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC) and at the Baseline Performance Review (BPR).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.6 Annual Performance Indicators

Annual Performance Indicator 4.2.6: SFS-17-5

Year	Description
Rating	**Green**
2017	SFS-17-5: Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success.
2018	SFS-18-5: Demonstrate Initial Operating Capability of the Tracking and Data Relay Satellite (TDRS)-M spacecraft.
2019	SFS-19-5: Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success.

Performance Goal 4.2.7

Replace the aging Deep Space Network (DSN) 70-meter antenna at Canberra Deep Space Communications Complex (CDSCC).

2017 Performance Results
Green

NASA's Space Communications and Navigation (SCaN) program manages the Deep Space Network (DSN), which is an international network of antennas that supports interplanetary spacecraft missions, space-based telescopes, ground-based radio astronomy, and some select Earth-orbiting science missions. The DSN comprises three facilities, the Canberra Deep Space Communications Complex in Australia; the Goldstone Deep Space Communications Complex in Fort Irwin, CA; and the Madrid Deep Space Communications Complex in Spain. The DSN supports NASA and non-NASA missions that explore the furthest points of the solar system.

To meet ongoing demand for deep space communication services, SCaN is augmenting its aging Deep Space Station (DSS) 70-meter antennas with a new generation of 34-meter antennas. Four 34-meter antennas can be arrayed to provide functionally similar capabilities to a 70-meter antenna. SCaN has completed two new 34-meter antennas, DSS-35 and DSS-36, at the Canberra Deep Space Communications Complex. The two new antennas can be arrayed with the existing two 34-meter antennas to provide redundancy and reduce dependency on the aging 70-meter antenna.

NASA achieved initial operational status of DSS-36 in early FY 2017. Over the next several years, NASA will continue work on installing new 34-meter antennas at the Madrid Deep Space Communications Complex.

Performance Goal 4.2.7 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.2.7)

Year	Description
2018	4.2.7: Replace the aging Deep Space Network (DSN) infrastructure.
2019	4.2.7: Replace the aging Deep Space Network (DSN) infrastructure.

Data Quality Elements

Data Source
NASA-internal presentation charts and link(s) to external press releases.

Verification and Validation
Review of the documentation listed under Data Sources by the Human Exploration and Operations Mission Directorate (HEOMD) Directorate Program Management Council (DPMC) and at the Baseline Performance Review (BPR).

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.7 Annual Performance Indicators

Annual Performance Indicator 4.2.7: SFS-17-7

Year	Description
Rating	**Green**
2017	SFS-17-7: Achieve initial operational status of Deep Space Station (DSS)-36 at Canberra Deep Space Communications Complex (CDSCC).
2018	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.
2019	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.

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.

2017 Performance Results
Green

The NASA Space Environments Testing Management Office (SETMO) ensures that essential Agency test facilities are maintained in a state of readiness. SETMO 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; to ensure that capabilities include the right mix of the facilities, equipment, core competencies, and skilled staff; and to identify and prioritize NASA's essential assets, and implement strategic investment decisions to sustain, enhance, replace, modify, or dispose of them based on NASA and National needs. Core capabilities supported within SETMO include thermal vacuum chambers, simulators, and the Arc Jet Complex.

SETMO asset capabilities continue to be available for programs and projects with no major impacts to critical programs and projects milestones. In FY 2017, the overall availability for SETMO assets was 97.8 percent.

Performance Goal 4.2.8 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Green

Planned Future Performance (PG 4.2.8)

Year	Description
2018	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.
2019	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 Quality Elements

Data Source
Quarterly program reviews by SETMO.

Verification and Validation
Assessment by SETMO staff at the Quarterly Program Reviews.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.2.8 Annual Performance Indicators

Annual Performance Indicator 4.2.8: SC-17-1

Year	Description
Rating	**Green**
2017	SC-17-1: 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.
2018	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.
2019	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.

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

Contributing Programs/Projects:
Program elements consist of work managed by OSMA, including the NASA Safety Center and the Independent Verification and Validation Program; the Office of the Chief Engineer, including the NASA Engineering and Safety Center; and the Office of the Chief Health and Medical Officer

Objective Overview

Safety and Mission Success (SMS) programs include programs that provide technical excellence, mission assurance, and technical authority. The elements of SMS reflect the recommendations outlined in many studies and by advisory boards and panels. These programs directly support NASA's core values and serve to improve the likelihood for NASA's programs, projects, and operations to achieve mission success while protecting the health and safety of NASA's workforce.

SMS programs protect the health and safety of the NASA workforce and improve the likelihood that NASA's programs, projects, and operations are completed safely and successfully. They contribute to the Agency's SMS by establishing applicable safety, engineering, and health policy directives and procedural requirements. Furthermore, SMS programs assure that directives and requirements are appropriately implemented, and perform independent technical analysis of safety and mission critical software products.

SMS programs develop policy and procedural requirements and provide assessments and recommendations to the Administrator, mission directorates, Center directors, and program managers who are ultimately responsible for the SMS of all NASA activities. SMS resources provide the foundation for NASA's system of checks and balances, enabling the effective application of the strategic management framework and the technical authorities defined in NASA's *Strategic Management and Governance Handbook*. SMS programs enable risk-informed decision making by providing independent assessments of the technical challenges, independent technical analysis of safety and mission critical software products, and risks encountered by programs and projects. SMS practices verify that all pertinent policy and procedures have been followed or appropriate waivers have been obtained. The programs also participate in Key Decision Point meetings and the Agency's Baseline Performance Reviews.

Strategic Objective 4.3 Data Summary

Performance Goal Ratings (4.3.1 - 4.3.2)

Fiscal Year	Total	Green	Yellow	Red	White
2017	2	2	0	0	0
2016	2	2	0	0	0
2015	2	2	0	0	0
2014	2	2	0	0	0
2013	1	1	0	0	0
2012	1	1	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	5	5	0	0	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

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.

2017 Performance Results
Green

During FY 2017, NASA continued to assure the safety and health of its activities and minimized the damage to its assets. This was demonstrated by the following:

- There were no fatalities or permanent disabling injuries to the public from NASA activities.
- NASA's Total Case Rate and Lost Time Case Rate were under the Federal injury and illness goals administered by the Office of Workers' Compensation Programs. 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 was significantly under one injury or illness per 100 employees per year, with an FY 2017 Total Case Rate of 0.18, and a Lost Time Case Rate of only 0.02.
- The non-mission failure damage costs were significantly below the five-year running average. In FY 2017, NASA's non-mission failure damage costs were $6.1 million and its five-year running average is $3.8 million, both below the target of $6.5 million.

NASA's strategy to achieve this performance goal is based on the integration of its program portfolio and mission support activities, while utilizing its strong governance structure, risk analysis, and business practices. At the core of the Agency's preventive approach to achieve safety, health, and mission success are:

- Active engagement with NASA programs and institutions to advise, advocate, and ensure safety and mission success;
- Routine onsite inspections and regular self-audits to ensure compliance with mandatory regulations, Agency policies, industry standards, and best practices;
- Robust knowledge management and communities of practice that capture and inculcate lessons learned into future missions;
- Multi-faceted training and development programs to ensure that the Safety and Mission Success workforce has the necessary skills and capabilities; and
- Comprehensive review processes to identify and mitigate risks and analyze and understand failures when they occur.

This strategy and practice provides a systematic approach to support safety and mission success.

More Safety and Mission Success information is available on NASA's websites for the Office of the Chief Engineer, Office of the Chief Health and Medical Officer, Office of Safety and Mission Assurance, and Independent Verification and Validation (IV&V) Program.

Performance Goal 4.3.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.3.1)

Year	Description
2018	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.
2019	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 Quality Elements

Data Source
NASA Mishap Information System (NMIS).

Verification and Validation
Quarterly review of the data listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.3.1 Annual Performance Indicators

Annual Performance Indicator 4.3.1: AMO-17-19

Year	Description
Rating	**Green**
2017	AMO-17-19: Assure zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2017.
2018	AMO-18-25: Achieve zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2018.
2019	AMO-19-13: Achieve zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2019.

Annual Performance Indicator 4.3.1: AMO-17-20

Year	Description
Rating	**Green**
2017	AMO-17-20: Maintain a Total Case Rate and Lost Time Case Rate that meets or exceeds the goals of the Administration.
2018	AMO-18-26: Maintain a Total Case Rate and Lost Time Case Rate below 1.0 cases per 100 employees.
2019	AMO-19-14: Maintain a Total Case Rate and Lost Time Case Rate below 1.0 cases per 100 employees.

Annual Performance Indicator 4.3.1: AMO-17-21

Year	Description
Rating	**Green**
2017	AMO-17-21: Reduce damage to NASA assets (excluding launched flight hardware) by two percent per year through FY 2017, compared to an FY 2010 baseline (in real dollars).
2018	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).
2019	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).

Annual Performance Indicator 4.3.1: AMO-18-34

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	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.

Performance Goal 4.3.2

Implement the policies, procedures and oversight to continuously improve the probability of technical and programmatic mission success.

2017 Performance Results
Green

NASA continued implementing the policies, procedures, and oversight necessary to improve the probability of technical and programmatic mission success. Projects are assigned to Category 1, 2, or 3 based on the estimated lifecycle costs and priority level. During FY 2017, 100 percent of Category 1 and 2 projects complied with Safety and Mission Success policies and procedures. Specifically, all Category 1 and 2 projects that conducted lifecycle reviews were also subject to independent assessments; all Category 1 and 2 projects either were executing to an approved plan or were in an approved rebaseline planning cycle; and the NASA Engineering and Safety Center (NESC) had the capability and capacity to accept all requested assessments of Category 1 and 2 projects.

In addition, the entire engineering and programmatic workforce had access to the standards and knowledge base necessary to maintain and build their skills. NASA's Academy of Program/Project and Engineering Leadership (APPEL) maintains remote database and reference material capabilities to ensure that 100 percent of NASA's project management community has access to the materials needed to achieve or maintain certification requirements. The materials required by the workforce are maintained on an Agency-accessible community of practice knowledge website, supporting access to the NESC academy and standards materials. For FY 2017, there were no reported non-scheduled outages of the website. The NASA Engineering Network availability was 99.73 percent, exceeding requirements.

More Safety and Mission Success information is available on NASA's websites for the Office of the Chief Engineer, Office of the Chief Health and Medical Officer, Office of Safety and Mission Assurance, and Independent Verification and Validation (IV&V) Program.

Performance Goal 4.3.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Green	Green	Green

Planned Future Performance (PG 4.3.2)

Year	Description
2018	4.3.2: Implement the policies, procedures, and oversight to continuously improve the probability of technical and programmatic mission success.
2019	4.3.2: Implement the policies, procedures, and oversight to continuously improve the probability of technical and programmatic mission success.*

*NASA will revise or replace this performance goal with a more outcome-oriented measure in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Data Quality Elements

Data Source
Baseline Performance Review (BPR) meetings.

Verification and Validation
Quarterly reviews noted under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.3.2 Annual Performance Indicators

Annual Performance Indicator 4.3.2: AMO-17-22

Year	Description
Rating	**Green**
2017	AMO-17-22: Ensure 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.
2018	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.
2019	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.*

*NASA will revise or replace this annual performance indicator with a more outcome-oriented measure in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Annual Performance Indicator 4.3.2: AMO-17-23

Year	Description
Rating	**Green**
2017	AMO-17-23: Ensure that 100 percent of the engineering and programmatic workforce has access to the standards and knowledge base needed to maintain and build their skills.
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.
2019	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.*

*NASA will revise or replace this annual performance indicator with a more outcome-oriented measure in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Annual Performance Indicator 4.3.2: AMO-18-35

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
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.
2019	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.

Annual Performance Indicator 4.3.2: AMO-18-40

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
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.
2019	AMO-19-37: Achieving Agency strategic goals depends on adhering to aggressive schedules and avoiding resource expenditures and risk incurrence associated with delayed implementation. During FY 2019, 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.

Strategic Objective 4.4

Manage human capital.

Lead Office:
Mission Support Directorate (MSD) and Office of Human Capital Management (OHCM)

Contributing Programs/Projects:
Agency Management (OHCM and Office of Diversity and Equal Opportunity), Center Management and Operations

Goal Leader:
Daniel Tenney, Associate Administrator, MSD

Objective Overview

Mission success is highly dependent on a skilled, technical workforce. Through this management objective, NASA will attract, select, develop, deploy and retain competitive talent. NASA will enhance the efficiency and effectiveness of human capital service delivery in order to operate more like a business, taking on leaner postures through identification of efficiencies.

As one of the leading employers of science, technology, engineering, and mathematics (STEM) professionals, NASA seeks to optimize the Agency's technical solutions through a workforce reflective of diverse ideas, life experiences, and backgrounds. Complementary to a diverse workforce is a work environment characterized by the key principles of equal opportunity: equity, fairness, and career advancement (e.g., access to growth opportunities and mentoring).

Strategic Objective 4.4 Data Summary

Performance Goal Ratings (4.4.1 - 4.4.2)

Fiscal Year	Total	Green	Yellow	Red	White
2017	2	2	0	0	0
2016	2	2	0	0	0
2015	2	2	0	0	0
2014	2	2	0	0	0
2013	2	2	0	0	0
2012	2	2	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	3	3	0	0	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 4.4.1

Define and build diverse workforce skills and competencies needed for the Agency's mission.

2017 Performance Results
Green

NASA continues to build on its efforts to instill a culture of innovation in its workforce by recognizing and rewarding innovative performance; engaging and connecting the workforce to make it easy for employees to collaborate, network, and innovate; and creating an environment in which leaders view developing innovative employees as a productive and vital use of their time. Specifically:

- Recognizing and rewarding innovative performance: NASA continues its annual Innovation Awards to recognize, encourage, and celebrate a spirit of innovative behavior. The awards come in two categories. The Lean Forward; Fail Smart Award, which is available to both civil servants and contractors, is meant to propel individuals to lean forward, in spite of risk, consequently learning from the experience. The Champion of Innovation Award is intended for supervisors and managers who build a culture of appropriate risk taking, and who support and encourage creative and innovative behaviors from their employees. The NASA workforce both submits nominations and selects the winner in each category.
- Engaging and connecting the workforce: NASA is creating a workplace where geography is inconsequential and Agency work can be conducted anywhere and anytime by putting information, data, and tools at the fingertips of those individuals who need it. For example, NASA continues to expand the use of its telework program, which allows employees to perform their duties from home or another approved worksite, and to improve the tools available to employees for effective virtual collaboration.
- Building model supervisors and leaders: NASA ensures that first-line supervisors appreciate the importance of developing innovative employees. NASA infuses its leadership values into potential leaders early in their careers through Agency-level and Center-level leadership development programs. These include programs targeted to both aspiring and experienced supervisors, and have a heavy emphasis on personal effectiveness, relating to others, and self-reflection.

NASA's Innovation Index score increased from 81.0 percent in the 2016 Federal Employee Viewpoint Survey (FEVS) to 82.7 percent in the 2017 FEVS. This score is based on two separate indices in the FEVS, which include a set of three questions measuring the extent to which an individual employee feels encouraged and motivated to improve personal performance and deliver superior results; and a set of six questions centered around the workplace environment, from employee recognition for superior work to opportunities to demonstrate value and creative practices.

More information is available at http://nasapeople.nasa.gov/.

Performance Goal 4.4.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.4.1)

Year	Description
2018	4.4.1: Define and build diverse workforce skills and competencies needed for the Agency's Mission.
2019	4.4.1: Define and build diverse workforce skills and competencies needed for the Agency's Mission.

Data Quality Elements

Data Source
FEVS Innovation Index. Publicly available from the Office of Personnel Management (OPM) and Partnership for Public Service.

Verification and Validation
Review trends from the 2017 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 Limitations
None identified. OPM, which administers the FEVS, releases a technical report to accompany the survey results each year. The FEVS technical report includes detailed information on FEVS sample design and selection; the survey instrument; and data collection, cleaning and weighting, and analysis. OPM posts the survey results and FEVS technical reports to its https://www.fedview.opm.gov/ website.

The FEVS is distributed to the full population of eligible NASA participants, rather than sampling a portion of employees. By sending surveys to all eligible employees, there is no possibility of sampling non-representativeness in terms of survey distribution. It is possible that survey respondents differ from non-respondents, but this effect has been minimized by weighting survey responses based on socio-demographic variables, such as age, race, and gender. This weighting is intended to protect against unequal representation of some groups within NASA's workforce and to maximize the representativeness of the results.

Performance Goal 4.4.1 Annual Performance Indicators

Annual Performance Indicator 4.1.1: AMO-17-1

Year	Description
Rating	**Green**
2017	AMO-17-1: Sustain NASA's Innovation Score, as measured by the Innovation-related questions of the 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.
2018	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.
2019	AMO-19-20: 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.

Annual Performance Indicator 4.4.1: AMO-19-34

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	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.).

Performance Goal 4.4.2

Advance a workplace environment that affords equal employment opportunities (EEO) to all employees and takes proactive diversity and inclusion (D&I) efforts.

2017 Performance Results
Green

NASA continues to make progress toward this performance goal by implementing equal employment opportunity (EEO) programs and processes to proactively prevent discrimination and resolve issues and concerns as promptly and efficiently as possible. Examples include alternative dispute resolution (ADR) in the EEO complaints process, reasonable accommodations for individuals with disabilities, and the Anti-Harassment Program. Each of these programs and processes has been furthered in FY 2017 through concrete steps, such as innovative education and awareness opportunities and technical assistance to employee practitioners. In addition, using 2013 as a baseline, NASA achieved positive rates of change in the employment participation rates of some underrepresented EEO groups. Specifically, between 2013 and 2017, NASA increased the percentage of individuals with disabilities in its workforce by 14.6 percent. With regard to women and minorities in senior-level positions, NASA increased the percentage of women in those positions by 5.0 percent, African Americans by 13.3 percent, Asian American and Pacific Islanders by 1.8 percent, and Hispanics by 15.3 percent.

NASA focuses its diversity and EEO efforts on programs and processes that can help to reduce resource utilization by proactively preventing discrimination and more efficiently addressing workplace conflict when it arises. For example, EEO cases resolved through ADR take, on average, only 62 days to complete, compared to 367 days using the traditional discrimination complaint process. In FY 2017, there was a 100 percent resolution rate for formal EEO complaints that accepted ADR, and a 60 percent resolution rate for informal complaints that accepted ADR. NASA has also continued to vigorously administer its Anti-Harassment Program (AHP) and Reasonable Accommodations Program to proactively prevent discrimination. Under the AHP, the Agency kept processing times to an average of 53 days. The Agency issued new guidance to the Centers on the AHP, specifically focusing on new and emerging issues, to help Centers more effectively implement the program. In addition, management takes action in a high percentage of cases (27 percent) even where no harassment is found, which suggests the process is still helpful in addressing problematic behaviors regardless of whether the conduct is determined to be a violation of the Agency's anti-harassment policy. With NASA's Reasonable Accommodations Program, the Agency is developing updated procedures to introduce program upgrades, such as the use of personal assistance for employees with disabilities and new mechanisms to ensure that sufficient funds are available for more costly accommodations when necessary.

As an indicator of the continuing success of NASA's efforts in diversity and inclusion, the Agency's scores on the Office of Personnel Management's Inclusion Index of the Federal Employee Viewpoint Survey (FEVS) rose from 75 percent in the 2016 FEVS results to 78 percent in the 2017 results.

More information is available at NASA's Office of Diversity and Equal Opportunity website.

Performance Goal 4.4.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.4.2)

Year	Description
2018	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.
2019	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.

Data Quality Elements

Data Source
NASA Model Equal Employment Opportunity Agency Plan, Strategic Management Council, Diversity and Inclusion Strategic Partnership meetings, and Baseline Performance Review reporting.

Verification and Validation
Assessment of the NASA Model Equal Employment Opportunity Agency Plan and NASA Diversity and Inclusion Strategic Implementation Plan.

Data Limitations
Some lag time in reporting of data, particularly at the end of the fiscal year. The Office of Personnel Management (OPM), which administers the Federal Employee Viewpoint Survey (FEVS), releases an FEVS technical report to accompany the survey results each year. The FEVS technical report includes detailed information on FEVS sample design and selection; the survey instrument; and data collection, cleaning and weighting, and analysis. OPM posts the survey results and FEVS technical reports to its https://www.fedview.opm.gov/ website.

The FEVS is distributed to the full population of eligible NASA participants, rather than sampling a portion of employees. By sending surveys to all eligible employees, there is no possibility of sampling non-representativeness in terms of survey distribution. It is possible that survey respondents differ from non-respondents, but this effect has been minimized by weighting survey responses based on socio-demographic variables, such as age, race, and gender. This weighting is intended to protect against unequal representation of some groups within NASA's workforce and to maximize the representativeness of the results.

Performance Goal 4.4.2 Annual Performance Indicators

Annual Performance Indicator 4.4.2: AMO-17-2

Year	Description
Rating	**Green**
2017	AMO-17-2: Sustain three programs and processes designed to proactively prevent discrimination, as outlined in the Model EEO Agency Plan.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 4.4.2: AMO-17-3

Year	Description
Rating	**Green**
2017	AMO-17-3: Continue implementation of the NASA Diversity and Inclusion Strategic Implementation Plan FY 2016 to FY 2019.
2018	AMO-18-2: Continue implementation of the NASA Diversity and Inclusion Strategic Implementation Plan FY 2016 to FY 2019.
2019	No API this fiscal year.

Annual Performance Indicator 4.4.2: AMO-18-3

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
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.
2019	AMO-19-21: Improve employee perceptions relating to fairness and career advancement as measured by the Federal Employee Viewpoint Survey (FEVS) Inclusion Index percentages.

Annual Performance Indicator 4.4.2: AMO-18-23

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	AMO-19-35: 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.

Annual Performance Indicator 4.4.2: AMO-18-24

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	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.
2019	AMO-19-36: 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.

Performance Goal 4.4.3

Does not trend until FY 2019.

2017 Performance Results
N/A

This is a new performance goal in FY 2019.

Performance Goal 4.4.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 4.4.3)

Year	Description
2018	No PG this fiscal year.
2019	4.4.3: Preserve and grow NASA's culture and brand by engaging the workforce and building model supervisors and leaders.

Data Quality Elements

Data Source
Federal Employee Viewpoint Survey (FEVS) Employee Engagement, Leaders Lead, and Supervisor Indices. Publicly available from the Office of Personnel Management (OPM) and Partnership for Public Service.

Verification and Validation
Review trends from the 2017 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 Limitations
None identified. The OPM, which administers the FEVS, releases a technical report to accompany the survey results each year. The FEVS technical report includes detailed information on FEVS sample design and selection; the survey instrument; and data collection, cleaning and weighting, and analysis. OPM posts the survey results and FEVS technical reports to its https://www.fedview.opm.gov/ website.

The FEVS is distributed to the full population of eligible NASA participants, rather than sampling a portion of employees. By sending surveys to all eligible employees, there is no possibility of sampling non-representativeness in terms of survey distribution. It is possible that survey respondents differ from non-respondents, but this effect has been minimized by weighting survey responses based on sociodemographic variables, such as age, race, and gender. This weighting is intended to protect against unequal representation of some groups within NASA's workforce and to maximize the representativeness of the results.

Performance Goal 4.4.3 Annual Performance Indicators

Annual Performance Indicator 4.4.3: AMO-19-31

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	AMO-19-31: Sustain NASA's Employee Engagement index, as measured by Federal Employee Viewpoint Survey (FEVS), by refining and updating human capital policies, programs, and systems to sustain a workplace environment that supports employee engagement.

Annual Performance Indicator 4.4.3: AMO-19-32

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	AMO-19-32: Sustain NASA's Leaders Lead index, as measured by the Federal Employee Viewpoint Survey (FEVS), by refining and updating human capital policies, programs, and systems to support effective leaders at all levels who serve as role models, develop their people, and facilitate NASA's culture and operating environment.

Annual Performance Indicator 4.4.3: AMO-19-33

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	AMO-19-33: Sustain NASA's Supervisor index, as measured by the Federal Employee Viewpoint Survey (FEVS), by refining and updating human capital policies, programs, and systems to support model supervisors who communicate effectively, focus on employee development, and foster mutual trust, confidence, and respect.

Strategic Objective 4.5

Ensure enterprise protection.

Lead Office:
Principal Advisor for Enterprise Protection and Office of the Chief Information Officer (OCIO)

Goal Leader:
Renee Wynn, Chief Information Officer, and Ray Taylor, Principal Advisor for Enterprise Protection

Contributing Programs/Projects:
Enterprise Protection Program, Agency Information Technology Services, Agency Management (Office of Protective Services and Office of Strategic Infrastructure)

Objective Overview

Enterprise systems include NASA's mission programs and projects, information systems, and supporting institutional infrastructure. These systems are at risk of having disrupted, degraded, or denied environments due to natural, accidental, and malicious threats. This threat climate prompts the need for comprehensive risk assessments and risk-based safeguards for NASA's capabilities, technologies, and intellectual property. Insight, coordination, and action across the Agency will reduce the likelihood and consequences of enterprise protection risk.

NASA shares responsibility across its missions and mission support organizations to safeguard against these threats by operationalizing effective, innovative, and economical protections. The Agency's protection approach focuses on understanding, communicating, controlling, and, as appropriate, accepting these risks to the achievement of the Agency's objectives. This approach aligns with and supports the Agency's overarching enterprise risk management framework, as well as Federal laws and policies for requirements such as cybersecurity. The Agency will balance its protections with appropriate openness and transparency to promote accessibility and citizen engagement in NASA's missions.

Strategic Objective 4.5 Data Summary

Performance Goal Ratings (4.5.1 - 4.5.4)

Fiscal Year	Total	Green	Yellow	Red	White
2017	5	4	1	0	0
2016	5	3	1	1	0
2015	4	4	0	0	0
2014	1	0	1	0	0
2013	0	0	0	0	0
2012	0	0	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	8	3	5	0	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 4.5.1

Enhance NASA's information security posture through implementation of automated security and privacy tools and technologies.

2017 Performance Results
Yellow

NASA's Office of the Chief Information Officer (OCIO) continues to make progress toward achieving this cybersecurity performance goal.

NASA deployed Continuous Diagnostics and Mitigation (CDM) Phase 1 tools across 95 percent of its corporate environment to strengthen its IT asset management. The Agency is implementing CDM Phase 2 to increase access control capabilities across NASA's environments Agency-wide. The Agency will complete deployment of the CDM Phase 2 capabilities by the second quarter of FY 2019.

The Agency maintained 72.9 percent Personal Identification Verification (PIV) strong authentication for non-privileged user access through machine-based enforcement at the end of FY 2017. This level was less than the target of 85 percent for FY 2017 set in accordance with the Federal Information Security Modernization Act (FISMA). The Agency maintained 100 percent strong authentication for privileged user access, meeting the FISMA target level. The Agency exceeds the target set under FISMA for anti-phishing and is working to increase its score for blended defense.

Performance Improvement Plan

The Agency will complete deployment of the CDM Phase 1 capabilities across the corporate environment by the fourth quarter of FY 2018. NASA's deployment of CDM Phase 2 across the remaining environments is planned by the second quarter of FY 2019. NASA redistributed resources to support implementation of three related products and is meeting with vendors and the Department of Homeland Security periodically to help meet scheduled milestones.

NASA established an implementation plan for its PIV solutions and is actively executing this plan to increase the Agency's PIV strong authentication protection and meet the target set under FISMA.

Performance Goal 4.5.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Yellow	Green	Red	Yellow

Planned Future Performance (PG 4.5.1)

Year	Description
2018	4.5.1: Safeguard NASA's data and IT assets by implementing cybersecurity and privacy capabilities.
2019	4.5.1: Safeguard NASA's data and IT assets by implementing cybersecurity and privacy capabilities.

Data Quality Elements

Data Source

Quarterly President's Management Council (PMC) cybersecurity assessments for the maturity of specific cybersecurity capabilities.

Verification and Validation
Review of quarterly President's Management Council (PMC) cybersecurity assessments.

Data Limitations
Data regarding specific protections may be sensitive. Data are sufficiently accurate for their intended use.

Performance Goal 4.5.1 Annual Performance Indicators

Annual Performance Indicator 4.5.1: AMO-17-25

Year	Description
Rating	**Yellow**
2017	AMO-17-25: Increase the security of NASA's information operations by implementing the FY 2017 target cross-agency priority cybersecurity capabilities, including Information Security Continuous Monitoring (ISCM); Identity, Credential, and Access Management (ICAM); and anti-phishing and malware defense.
2018	AMO-18-18: Attain 95 percent multi-factor authentication for non-privileged access to hardware in the corporate environment.
2019	AMO-19-22: Attain 90 percent multi-factor authentication for non-privileged access to user accounts in the corporate environment.

Explanation of Rating
As noted above, NASA established an implementation plan for its PIV solutions and is actively executing this plan to increase the Agency's PIV strong authentication protection and meet the target set under FISMA.

Annual Performance Indicator 4.5.1: AMO-17-17

Year	Description
Rating	**Yellow**
2017	AMO-17-17: Plan and implement Continuous Diagnostics and Mitigation (CDM) Phase 2 tools and technologies into the NASA environment.
2018	No API this fiscal year.
2019	No API this fiscal year.

Explanation of Rating
NASA's deployment of CDM Phase 2 across the remaining environments is planned by the second quarter of FY 2019. NASA redistributed resources to support implementation of three related products and is meeting with vendors and the Department of Homeland Security periodically to help meet scheduled milestones.

Annual Performance Indicator 4.5.1: AMO-18-19

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	AMO-18-19: Attain Hardware and Software Asset Management of 95 percent for the corporate environment.
2019	No API this fiscal year.

Annual Performance Indicator 4.5.1: AMO-19-23

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	No API this fiscal year.
2019	AMO-19-23: Enforce a 30-minute inactivity time-out for remote access security.

Performance Goal 4.5.2

Does not trend until FY 2018.

2017 Performance Results
N/A

This is a new performance goal in FY 2018.

Performance Goal 4.5.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 4.5.2)

Year	Description
2018	4.5.2: Formalize NASA's enterprise protection structure and execution across the Agency and its Federal, commercial, and international partners to increase enterprise protection effectiveness.
2019	4.5.2: Formalize NASA's enterprise protection structure and execution across the Agency and its Federal, commercial, and international partners to increase enterprise protection effectiveness.*

*NASA will revise or replace this performance goal with a more outcome-oriented measure in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Data Quality Elements

Data Source
Records pertaining to enterprise protection structure and other internal documentation.

Verification and Validation
Review of the documentation listed under Data Sources.

Data Limitations
Data regarding specific protections may be sensitive. Data are sufficiently accurate for their intended use.

Performance Goal 4.5.2 Annual Performance Indicators

Annual Performance Indicator 4.5.2: AMO-18-36

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	AMO-18-36: Establish the Enterprise Protection Board to drive integrated enterprise protection risk management and Agency-level direction regarding protection risk.
2019	AMO-19-24: Conduct three Enterprise Protection Board meetings to address integrated NASA enterprise protection.*

*NASA will revise or replace this annual performance indicator with a more outcome-oriented measure in its *FY 2020 Volume of Integrated Performance*, scheduled for release on February 4, 2019.

Performance Goal 4.5.3

Does not trend until FY 2018.

2017 Performance Results
N/A

This is a new performance goal in FY 2018.

Performance Goal 4.5.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	No PG	No PG

Planned Future Performance (PG 4.5.3)

Year	Description
2018	4.5.3: Achieve improvements in overall Office of Protective Services physical security operations, standardization, efficiencies, and economies of scale.
2019	4.5.3: Achieve improvements in overall Office of Protective Services physical security operations, standardization, efficiencies, and economies of scale.

Data Quality Elements

Data Source
Integrated Security Functional Review (ISFR) functional review report(s), formal Federal Law Enforcement Training Accreditation (FLETA) certificates, and NASA-internal reports.

Verification and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.5.3 Annual Performance Indicators

Annual Performance Indicator 4.5.3: AMO-18-38

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
2018	AMO-18-37: Deploy NASA's Visitor Management System for U.S. citizens, then enhance system to include visitor management for foreign nationals.
2019	No API this fiscal year.

Annual Performance Indicator 4.5.3: AMO-18-39

Year	Description
Rating	**N/A**
2017	No API this fiscal year.
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.
2019	AMO-19-25: Maintain Federal Law Enforcement Training Accreditation (FLETA) Federal Arrest Authority (FAA) programmatic accreditation and Academy accreditation.

Legacy Performance Goal*

By 2017, operate as a single NASA enterprise network and effectively utilize the bandwidth of the Communications Services Office (CSO) backbone for both corporate and mission data, enabling more efficient use of available capacity while improving performance with no degradation to mission services.

2017 Performance Results
Green

**Performance Goal 3.3.5 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 4.5. (This performance goal, 3.3.5, aligns to the* 2014 Strategic Plan *framework.)*

NASA completed the Mission Backbone Transition (MBT) project in November 2017, slightly behind schedule. MBT is the final phase of NASA's multiyear effort to optimize its communications backbone infrastructure. The goal of this project is for NASA to fully leverage its implementations of the Mission Next Generation Architecture and Backbone Equipment Refresh products to reduce cost and improve service delivery.

Performance Goal 3.3.5 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	Green	Yellow	Green

Planned Future Performance (PG 3.3.5)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Performance Goal 3.3.5 Annual Performance Indicators

Annual Performance Indicator 3.3.5: AMO-17-26

Year	Description
Rating	Yellow
2017	Complete the Mission Backbone Transition (MBT) project.
2018	No API this fiscal year.
2019	No API this fiscal year.

Explanation of Rating

As noted above, NASA completed the MBT project slightly behind schedule. MBT is a four-year project that supports optimization of the Agency's communications backbone infrastructure to enable cost savings, cybersecurity, and service agility. The project culminated in 2017 with network transitions from the Agency's existing mission backbone services to the Mission Next Generation Architecture network. The Agency completed 17 of the 21 network transitions as planned by the end of FY 2017. NASA completed two more transitions in October 2017, and the final two transitions in November 2017. This schedule change accounts for four percent of the project's overall timeline. This delay was due to managing these network transitions around NASA's mission support and operations schedules and commercial carrier provisioning issues. Deployment of cybersecurity upgrades for Continuous Diagnostics and Mitigation (CDM) also impacted MBT transition support, since the MBT team needed to resolve conflicts related to CDM implementation. The MBT project completed within budget.

Legacy Performance Goal*

Enhance NASA's data management through open data actions, research and development data access, and new data modeling and technologies.

2017 Performance Results
Green

**Performance Goal 3.3.6 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 4.5. (This performance goal, 3.3.6, aligns to the* 2014 Strategic Plan *framework.)*

NASA continues to make progress toward achieving this performance goal. The Agency updated the open data platform at data.nasa.gov to improve access to datasets and visualizations. NASA cataloged approximately 32,000 open datasets on https://data.nasa.gov/ and cataloged thousands of machine-readable application programming interface endpoints and data products on https://api.nasa.gov/. More than 40 citizen applications are using these open data resources. Additional applications were built in NASA hackathons such as the SpaceApps Challenge. NASA also inventoried its sharing of source code. This inventory is browsable on https://code.nasa.gov/, currently sharing 331 open source projects.

The Agency is leveraging its applied data architecture, management, and analytics for programs, including Extra Vehicular Activities (EVA) and Exploration Medical Capabilities (ExMC), a data governance framework, a data integration platform, data analytics, and data standards to help its customers. NASA is using a Federated Source Code System that aims to apply new metadata standards to describe source code projects and drastically improve source code reuse within the Agency. NASA is also using open data standards to internally catalog and map datasets along with application of data science and machine learning techniques to generate smarter keywords and automate relevancy measures between existing information assets.

NASA began development of a platform that will offer the Agency new data management and analytics capabilities. NASA's intent is to be able to reuse or repurpose these capabilities to meet varying mission needs. The Agency expects to complete implementation of the initial platform in FY 2018.

The Agency is making progress on expanding the availability of its research and development data and publications. At the end of FY 2017, the National Institutes of Health (NIH) PubMed Central repository contained 5,542 NASA-funded peer-reviewed publications available for public access. These publications originated from NASA civil servants and NASA-affiliated authors.

Performance Goal 3.3.6 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	Green	Green	Green

Planned Future Performance (PG 3.3.6)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
NASA-internal reports on enterprise wide data tools.

Verification and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.3.6 Annual Performance Indicators

Annual Performance Indicator 3.3.6: AMO-17-27

Year	Description
Rating	**Green**
2017	Enable customers to utilize information architecture to drive opportunities for new insights using NASA data.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 3.3.6: AMO-17-28

Year	Description
Rating	**Yellow**
2017	Expand availability of R&D data and publications through secure use of shared hosting and data infrastructure.
2018	No API this fiscal year.
2019	No API this fiscal year.

Explanation of Rating

The Agency expects to reach 10,000 publications from NASA civil servants and NASA-affiliated authors on PubMed Central by FY 2020. The Agency is evaluating methods to increase the efficiency and effectiveness of the publication process. The Agency added language to NASA-funded grants and cooperative agreements to require principal investigators to submit a data management plan and deposit peer-reviewed manuscripts into the PubMed Central system. However, the increase in deposits to the PubMed Central repository can experience a natural delay of three years or more as researchers conduct their studies prior to publishing their work. In the meantime, NASA is adding requirements to upgrade its legacy grant and procurement infrastructure to better track the grant award through the publication life cycle, which will enable better reporting of NASA-affiliated publications.

Legacy Performance Goal*

Increase the adoption of technologies and services such as cloud computing throughout NASA's infrastructure and mission, leveraging savings from solutions such as reduced capital expenditures from not owning hardware, benefits from new technology capabilities, and increased computing flexibility available with "pay as you go" services.

2017 Performance Results
Green

**Performance Goal 3.3.7 was retired with the* 2014 Strategic Plan *and does not trend into the new 2018 strategic plan framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 4.5. (This performance goal, 3.3.7, aligns to the* 2014 Strategic Plan *framework.)*

NASA continued to make progress toward achieving this performance goal. The Cloud Computing Service Office has on-boarded five significant cloud communities since FY 2015, including the Cloud Access Security Broker in FY 2017, which will provide continuous discovery and monitoring for cloud computing across NASA. The Agency is also making progress to onboard the managed cloud environment at the Johnson Space Center. This effort will be completed in FY 2018.

Performance Goal 3.3.7 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	Green	Green	Green

Planned Future Performance (PG 3.3.7)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Data Quality Elements

Data Source
NASA-internal reports on enterprise wide data tools.

Verification and Validation
Review of the documentation listed under Data Sources.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 3.3.7 Annual Performance Indicators

Annual Performance Indicator 3.3.7: AMO-17-29

Year	Description
Rating	**Yellow**
2017	Onboard two significant communities into the cloud in FY 2017.
2018	No API this fiscal year.
2019	No API this fiscal year.

Explanation of Rating

NASA's Cloud Computing Service Office has worked to onboard two offerings to the cloud in FY 2017. The Agency implemented the Cloud Access Security Broker, which will provide continuous discovery and monitoring for cloud computing across NASA. The Agency is also making progress to onboard the managed cloud environment at the Johnson Space Center, which will be completed in FY 2018.

Legacy Performance Goal*

By 2017, increase Agency business systems performance and efficiency by upgrading NASA's business systems infrastructure and modernizing business applications with no degradation to business services.

2017 Performance Results
Green

**Performance Goal 3.3.8 was retired with the* 2014 Strategic Plan *and does not trend into the new* 2018 Strategic Plan *framework. For 2017 reporting purposes, goal content was aligned to Strategic Objective 4.5.*

NASA has completed this performance goal. The Agency completed the NASA Aircraft Management Information System–Logistic Upgrade (NAMIS-LU) project in November 2016. The NAMIS tracks grounding discrepancies, inspections, aircraft configurations, and crew flight status; provides continuous and active control of all assets, including materials, parts, and equipment; and provides data and metrics to support business decisions and financial reporting. The Logistics Upgrade project replaced the outdated programming platform with an industry standard.

NASA also completed the Contract Management Transformation (CMT) project in June 2017. The CMT project provided an end-to-end procurement solution as part of a single, commercial off-the-shelf product designed to seamlessly integrate with NASA's core financial system. The project was designed to help standardize processes and provide additional paperless functionality.

Performance Goal 3.3.8 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	Green	Green

Planned Future Performance (PG 3.3.8)

Year	Description
2018	No PG this fiscal year.
2019	No PG this fiscal year.

Performance Goal 3.3.8 Annual Performance Indicators

Annual Performance Indicator 3.3.8: AMO-17-18

Year	Description
Rating	Green
2017	Complete the Contract Management Transformation (CMT) project.
2018	No API this fiscal year.
2019	No API this fiscal year.

Annual Performance Indicator 3.3.8: AMO-17-31

Year	Description
Rating	**Green**
2017	Complete the NASA Aircraft Management Information System – Logistic Upgrade (NAMIS-LU) project.
2018	No API this fiscal year.
2019	No API this fiscal year.

Strategic Objective 4.6

Sustain infrastructure capabilities and operations.

Lead Office:
Mission Support Directorate (MSD)

Contributing Programs/Projects:
Center Management and Operations, Office of Strategic Infrastructure

Goal Leader:
Daniel Tenney, Associate Administrator, MSD

Objective Overview

Through this management objective, NASA is integrating and optimizing operations across Centers and mission support areas to reduce costs and revitalize the capabilities required to enable NASA's portfolio of missions. To address challenges associated with aging infrastructure, NASA is aggressively managing its facility portfolio to consolidate and modernize into fewer, more efficient, and sustainable facilities. Through a systematic assessment of service areas, NASA is consolidating and improving operations to balance risks across services and activities to provide a safe and reliable infrastructure.

Strategic Objective 4.6 Data Summary

Performance Goal Ratings (4.6.1 - 4.6.3)

Fiscal Year	Total	Green	Yellow	Red	White
2017	3	2	0	1	0
2016	3	1	1	1	0
2015	2	1	1	0	0
2014	2	2	0	0	0
2013	1	1	0	0	0
2012	1	1	0	0	0

Annual Performance Indicator Ratings

Fiscal Year	Total	Green	Yellow	Red	White
2017	5	4	0	1	0

Previous fiscal years only include performance goals (PGs) and annual performance indicators (APIs) that trend to the current fiscal year PGs and APIs, respectively.

Performance Goal 4.6.1

Between 2012 and 2017, support the demolition and elimination of obsolete and unneeded facilities.

2017 Performance Results
Green

NASA demolishes obsolete, unneeded infrastructure in order to improve efficiency and mitigate safety and environmental risks. The program, which has been in operation for over a decade, is an important part of NASA's efforts to reduce its infrastructure and operating costs. NASA's Office of Strategic Infrastructure evaluates unused and unneeded facilities on a regular basis, and has made progress toward reducing the Agency's overall footprint through demolition.

In FY 2017, NASA initiated demolition actions for facilities at five Centers:

- Atmospheric Reentry Materials and Structures Evaluation Facility at the Johnson Space Center;
- H.J.E Reid Conference Center at the Langley Research Center;
- Administrative Support Building at the Goddard Space Flight Center;
- Special Projects Laboratory at the Glenn Research Center; and
- Lidar (light detection and ranging) Facility at the Marshall Space Flight Center.

NASA identifies facilities for demolition through special studies, which determine if the facility is required for current or future missions. Facilities that are no longer needed are included in a five-year demolition plan that sets project schedules based on last need (both mission and date), annual costs avoided if the facility is demolished, potential liability, and project execution factors. Facilities included in the five-year plan occasionally are adjusted due to consultation with states on historic properties, changes in operational schedules, environmental remediation, funding profiles, local market forces, and the value of recycled materials.

More information is available at NASA's Office of Strategic Infrastructure website.

Performance Goal 4.6.1 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	Green	Green	Green	Green	Green	Green

Planned Future Performance (PG 4.6.1)

Year	Description
2018	4.6.1: Between 2012 and 2018, support the demolition and elimination of obsolete and unneeded facilities.
2019	4.6.1: Between 2018 and 2022, support the demolition and elimination of obsolete and unneeded facilities.

Data Quality Elements

Data Source
Quarterly budget and excess property reports.

Verification and Validation
Review of the documentation listed under Data Source.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.6.1 Annual Performance Indicators

Annual Performance Indicator 4.6.1: COF-17-1

Year	Description
Rating	Green
2017	COF-17-1: Initiate the demolition or disposal of five facilities or structures during 2017 to reduce the Agency's footprint.
2018	COF-18-1: Initiate the demolition or disposal of five facilities or structures during 2018 to reduce the Agency's footprint.
2019	COF-19-1: Dispose of 20 facilities or structures during 2019 to reduce the Agency's footprint.

Performance Goal 4.6.2

Ensure that NASA continues progress towards implementing statutory or Executive Order targets and goals reflected in its annual Sustainability Plan.

2017 Performance Results
Green

In FY 2017, NASA met the sustainability and energy targets that support this performance goal. NASA has a sustainability policy to execute its Mission without compromising the planet's resources, so that future generations can meet their needs. Sustainability also involves taking action now to provide a future where the environment and living conditions are protected and enhanced. In implementing sustainability practices, NASA manages risks to its missions, the environment, and local communities. To this end, NASA seeks to use public funds efficiently and effectively, promote the health of the planet, and operate in a way that benefits its neighbors.

Following were some of NASA's key sustainability activities:

- In FY 2016, NASA reduced its energy consumption per gross square feet (Btu/GSF) by 11.1 percent from the baseline set in FY 2015, achieving its goal for energy intensity. This success is a result of implementing energy conservation measures and onsite renewable energy projects. For example, NASA replaced an aging heating, ventilation, and air conditioning (HVAC) system in the Armstrong Headquarters building at the Armstrong Flight Research Center with a high-efficiency chiller system equipped with variable frequency pumps and variable air volume systems, all tied to a building automation system. In addition, the Kennedy Space Center (KSC) consolidated 45 thousand square feet of data centers from five different facilities and dozens of smaller server rooms and closets into a single, 16 thousand square foot facility, significantly improving the efficiency of its power usage.
- NASA increased its inventory of sustainable buildings to 20.5 percent, measured by GSF, meeting its multiyear goal. In FY 2016, NASA added two buildings with a combined area of approximately 21 thousand GSF to its portfolio of buildings meeting the Guiding Principles for High Performance and Sustainable Buildings. Both facilities received Leadership in Energy and Environmental Design (LEED) silver certification. The facilities included the KSC Data Center, referenced above, and the Main Security Gatehouse at the Glenn Research Center's Plum Brook Station.
- NASA met its renewable energy goal, with 12.8 percent of electricity coming from renewable sources. NASA follows an Agency-wide strategy that emphasizes identifying large projects that can make a significant difference for the Agency, in addition to initiating smaller projects at each Center. For example, NASA completed a 295-kilowatt solar photovoltaic (PV) rooftop system in FY 2016, and plans to complete two ground-mounted solar PV systems in the roughly 1.5 megawatt range in FY 2017 and 2018. Where feasible, Centers are also bundling solar projects with larger facility upgrades or energy conservation measures to reduce payback periods. In addition, Centers are working closely with neighboring military facilities to increase opportunities for collaborative renewable energy projects.

In addition, NASA is completing the development of its first Agency-wide Energy Strategic Investment Plan. This plan will assess opportunities and inform decision making regarding the achievement of aggressive energy reduction, renewable energy, and greenhouse gas goals, while reducing the energy risk to NASA's missions. The plan will also be used to select energy projects for funding, as well as highlight opportunities for using third-party financing, such as through energy savings performance contracts and utility energy service contracts. Under such contracts, energy service companies and utility companies finance energy projects that NASA repays over time from avoided utility costs.

More information is available at NASA's Office of Strategic Infrastructure website.

Performance Goal 4.6.2 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	Green	Yellow	Yellow	Green

Planned Future Performance (PG 4.6.2)

Year	Description
2018	4.6.2: Ensure that NASA continues progress towards implementing the targets and goals reflected in its annual Sustainability Plan.
2019	4.6.2: Ensure that NASA continues progress towards implementing the targets and goals reflected in its annual Sustainability Plan.

Data Quality Elements

Data Source
Annual external reporting to the Department of Energy, Office of Management and Budget (OMB), and Council on Environmental Quality via the Energy-Greenhouse Gas Workbook; OMB Scorecard on Sustainability/Energy; and Strategic Sustainability Performance Plan.

Verification and Validation
Review of the documentation listed under Data Source.

Data Limitations
Lag time. Preliminary data are available in October or November after the end of the fiscal year, but final data typically are not available until January. Data are sufficiently accurate for their intended use.

Performance Goal 4.6.2 Annual Performance Indicators

Annual Performance Indicator 4.6.2: AMO-17-10

Year	Description
Rating	Green
2017	AMO-17-10: 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 2017 in the Sustainability and Energy Scorecard.
2018	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.
2019	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 for FY 2019 in the Sustainability and Energy Scorecard.

Annual Performance Indicator 4.6.2: AMO-17-11

Year	Description
Rating	**Green**
2017	AMO-17-11: 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 2017 in the Sustainability and Energy Scorecard.
2018	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.
2019	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 for FY 2019 in the Sustainability and Energy Scorecard.

Annual Performance Indicator 4.6.2: AMO-17-12

Year	Description
Rating	**Green**
2017	AMO-17-12: 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 2017 in the Sustainability and Energy Scorecard.
2018	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.
2019	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 for FY 2019 in the Sustainability and Energy Scorecard.

Performance Goal 4.6.3

Between 2016 and 2017, demonstrate increased facility reliability by reducing spending on unscheduled maintenance by two percent annually.

2017 Performance Results
Red

In FY 2015, the baseline year, NASA's ratio of the cost of unscheduled maintenance to the total cost of maintenance was 31.5 percent. In FY 2017, the ratio increased to 32.9 percent.

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 equipment; i.e., the higher the percentage, the poorer the condition. When these percentages are high, it indicates that equipment is not reliable, and unplanned failures and outages become more frequent, which can interrupt or delay direct mission activities, such as testing and manufacturing. This issue is exacerbated by the age of NASA's infrastructure. About 83 percent of NASA's infrastructure and facilities are currently beyond their constructed design life. However, with appropriate spending on maintenance, NASA can rebuild, repair, and, in some cases, replace the old, unreliable equipment. Unscheduled maintenance is significantly more expensive than scheduled maintenance. It can cost up to three times more to repair or replace equipment after it has failed, rather than keeping it in good working order. Due to resource constraints, NASA has deferred planned maintenance spending, which in some instances has led to an increase in unscheduled maintenance.

More information is available at NASA's Office of Strategic Infrastructure website.

Performance Improvement Plan

NASA has adopted a facilities maintenance and operation philosophy to support its missions by pursuing and adopting the safest, most cost-effective blend of reliability-centered maintenance (RCM) techniques, sustainability, safety procedures, and other best practices to provide safe, sustainable, efficient, and reliable facilities. NASA has set aside funding for RCM and condition-based maintenance (CBM) within the maintenance funding when available for Centers over the past few years, to invest in technology advancements that allow Centers to better manage maintenance resources.

While this is still an area of significant concern for NASA, the Agency is continuing efforts to divest facilities in poor condition and increase the use of RCM and CBM, which should help lower the ratio.

Performance Goal 4.6.3 Data Summary

Historical Performance

Fiscal Year	2012	2013	2014	2015	2016	2017
Rating	No PG	No PG	No PG	No PG	Red	Red

Planned Future Performance (PG 4.6.3)

Year	Description
2018	4.6.3: Between 2018 and 2019, demonstrate increased facility reliability by reducing spending on unscheduled maintenance by one percent annually.
2019	4.6.3: Between 2018 and 2019, demonstrate increased facility reliability by reducing spending on unscheduled maintenance by one percent annually.

Data Quality Elements

Data Source
Systems Application Products (SAP) and NASA Center work plans.

Verification and Validation
Review of the documentation listed under Data Source.

Data Limitations
None identified. Data are sufficiently accurate for their intended use.

Performance Goal 4.6.3 Annual Performance Indicators

Annual Performance Indicator 4.6.3: AMO-17-5

Year	Description
Rating	**Red**
2017	AMO-17-5: Reduce spending on unscheduled maintenance (out of total maintenance spending) by at least two percentage points.
2018	AMO-18-8: Reduce spending on unscheduled maintenance (out of total maintenance spending) by at least one percentage point.
2019	AMO-19-30: Reduce spending on unscheduled maintenance (out of total maintenance spending) by at least one percentage point.

Explanation of Rating

As noted above, NASA continues to divest facilities in poor condition and increase its efforts in reliability-centered maintenance and condition-based maintenance, which should help to lower the ratio.

Supporting Information

3

2018 Strategic Plan Mapping

To provide historical linkages, Figure 19 shows a mapping of the strategic goals and objectives from the *2014 Strategic Plan* to the newly-released *2018 Strategic Plan*. Of note, the four 2014 Science Mission Directorate strategic objectives have been merged into 2018 Strategic Objective 1.1, and the 2014 Mission Support Directorate content under Strategic Objective 3.1 has been divided into several different strategic objectives under Strategic Goals 3 and 4.

Figure 19. 2018 Strategic Plan Mapping to 2014 Strategic Plan

Strategic Goal 1: Expand Human Knowledge through New Scientific Discoveries.
1.1 Understand the Sun, Earth, Solar System, and Universe. (2014 Strategic Plan: 1.4, 1.5, 1.6, & 2.2)
1.2 Understand Responses of Physical and Biological Systems to Spaceflight. (2014 Strategic Plan: 1.2)
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. (2014 Strategic Plan: 1.2)
2.2 Conduct Human Exploration in Deep Space, Including to the Surface of the Moon. (2014 Strategic Plan: 1.1)
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. (2014 Strategic Plan: 1.1, 1.2, 1.7 & 2.3)
3.2 Transform Aviation through Revolutionary Technology Research, Development, and Transfer. (2014 Strategic Plan: 2.1)
3.3 Inspire and Engage the Public in Aeronautics, Space, and Science. (2014 Strategic Plan: 3.1)
Strategic Goal 4: Optimize Capabilities and Operations.
4.1 Engage in Partnership Strategies. (2014 Strategic Plan: 3.1)
4.2 Enable Space Access and Services. (2014 Strategic Plan: 1.2, 1.3, & 3.2)
4.3 Assure Safety and Mission Success. (2014 Strategic Plan: 3.4)
4.4 Manage Human Capital. (2014 Strategic Plan: 3.1)
4.5 Ensure Enterprise Protection. (2014 Strategic Plan: 3.3)
4.6 Sustain Infrastructure Capabilities and Operations. (2014 Strategic Plan: 3.1)

Changes to the FY 2018 Performance Plan

Each fiscal year, NASA's budget request to Congress contains an annual performance plan 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 annual performance plan update with the following year's budget request. 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:

- Eliminate the performance measure (do not rate the performance measure);
- Change the targeted performance (rate at the new target); or
- Move the performance measure to the following year's annual performance plan (do not rate until the following year).

Once the annual performance plan 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.

FY 2018 Performance Plan Update

NASA released the FY 2018 Performance Plan with its FY 2018 President's budget request in May 2017. Since then, NASA reviewed and updated the FY 2018 measures in light of the contents of the FY 2019 President's budget request, in consultation with the Office of Management and Budget, and updated its measures to reflect the priorities identified in the *2018 Strategic Plan*.

The following list shows the performance measures that have been added, changed, or removed for FY 2018. Only measures with substantive changes are shown.

Strategic Goal 1

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.

Removed: HE-18-6: Achieve the Ionospheric Connection Explorer (ICON) mission success criteria.

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

Changed: HE-18-7: Complete the selection for the Interstellar Mapping and Acceleration Probe (IMAP) Announcement of Opportunity.
Added: HE-18-8: Launch the Ionospheric Connection Explorer (ICON).

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

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.

Added: PS-18-12: Identify and catalog a cumulative 8,400 of the estimated 25,000 near-Earth asteroids (NEAs) 140 meters or larger.

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

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

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

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

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

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

Strategic Goal 2

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

Added: 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.

Added: 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.

Added: ISS-18-9: Issue an Announcement for Proposals (AFP) for the commercial use of low Earth orbit (LEO) for ongoing human spaceflight activities.
Added: ISS-18-13: Release a policy document on the commercial use of the International Space Station (ISS).
Added: ISS-18-10: Add at least two new in-orbit commercial International Space Station (ISS) facilities and/or facility managers during FY 2018.
Added: ISS-18-11: Sign agreements with at least 20 new National Laboratory customers during FY 2018.
Added: ISS-18-12: Sign agreements with at least 15 repeat National Laboratory customers during FY 2018.

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

Changed: ESD-18-1: Complete production of the Exploration Mission-1 Core Stage liquid oxygen tank.
Changed: 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.
Changed: ESD-18-3: Complete integrated verification and validation testing of the Mobile Launcher and the Vehicle Assembly Building.

Changed: 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)

Changed: 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.

Added: 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.

Added: PPE-18-1: Complete industry studies on potential synergies for a NASA-industry partnership to demonstrate a Power and Propulsion Element using advanced solar electric propulsion.

Strategic Goal 3

Retired (changed to "legacy"): Performance Goal 1.7.1: Explore and advance promising early stage solutions to space technology challenges through investment across the U.S. innovation community.

Removed: ST-18-1: Initiate at least 165 activities to research, study, or develop concepts for new technologies.

Retired (changed to "legacy"): Performance Goal 1.7.2: Advance technologies that offer significant improvement to existing solutions or enable new space science and exploration capabilities.

Removed: ST-18-2: Complete at least 75 percent of Game Changing Development program milestones, as established at the beginning of the fiscal year.

Retired (changed to "legacy"): Performance Goal 1.7.3: Mature new crosscutting space technology capabilities for demonstration.

Removed: ST-18-3: Complete three major milestones for small spacecraft projects to demonstrate game changing or crosscutting technologies in space.
Removed: ST-18-4: Complete four major milestones for Technology Demonstration Mission (TDM) technology development projects.

Retired (changed to "legacy"): Performance Goal 1.7.4: Engage the established commercial sector, emerging aerospace markets, and economic regions to leverage common interests and grow the National economy.

Removed: ST-18-5: Conduct at least three prize competitions.
Removed: ST-18-6: Create 15 opportunities for advancement beyond Phase II SBIR/STTR.
Removed: ST-18-7: Select and fly technology payloads from NASA, other government agencies, industry, and academia using flight services procured from at least five different commercial reusable suborbital or parabolic platform providers.

Changed: 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.

Added: 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.

Strategic Goal 4

Added: 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.

Added: AMO-18-30: Negotiate and sign at least 300 new partnership agreements with domestic, non-governmental parties.

Added: 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.

Added: 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.
Added: AMO-18-33: Implement a strategic training plan to promote the NASA Small Business Program.

Retired (changed to "legacy"): Performance Goal 3.1.5: Manage coordination of NASA's international and interagency activities in conjunction with the NASA mission directorates.

Removed: AMO-18-11: Implement the Agency-wide export control training program by facilitating at least 10 training sessions across the Agency.

Retired (changed to "legacy"): Performance Goal 3.1.9: Manage coordination of advisory committees' (NASA Advisory Council and Aerospace Safety Advisory Panel) recommendations to the NASA Administrator.

Removed: AMO-18-13: Provide NASA responses to advisory committees' recommendations made formally to the NASA Administrator.

Changed: 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.

Changed: 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.

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.

Changed: 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.

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.

Changed: AMO-18-26: Maintain a Total Case Rate and Lost Time Case Rate below 1.0 cases per 100 employees.

Added: 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.

Performance Goal 4.3.2: Implement the policies, procedures, and oversight to continuously improve the probability of technical and programmatic mission success.

Added: 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.
Added: 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.

Changed: 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.

Added: AMO-18-3: Improve employee perceptions relating to fairness and career advancement as measured by the Federal Employee Viewpoint Survey (FEVS) Inclusion Index percentages.
Added: 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.
Added: 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.

Changed: Performance Goal 4.5.1: Enhance NASA's information security posture through implementation of automated security and privacy tools and technologies.

Changed: AMO-18-18: Attain 95 percent multi-factor authentication for non-privileged access to hardware in the corporate environment.
Changed: AMO-18-19: Attain Hardware and Software Asset Management of 95 percent for the corporate environment.

Added: Performance Goal 4.5.2: Formalize NASA's enterprise protection structure and execution across the Agency and its Federal, commercial, and international partners to increase enterprise protection effectiveness.

Added: AMO-18-36: Establish the Enterprise Protection Board to drive integrated enterprise protection risk management and Agency-level direction regarding protection risk.

Added: Performance Goal 4.5.3: Achieve improvements in overall Office of Protective Services physical security operations, standardization, efficiencies, and economies of scale.

Added: AMO-18-37: Deploy NASA's Visitor Management System for U.S. citizens, then enhance system to include visitor management for foreign nationals.
Added: 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.

Retired (changed to "legacy"): Performance Goal 3.3.6: Enhance NASA's data management through open data actions, research and development data access, and new data modeling and technologies.

Removed: AMO-18-20: Provide analysis of needed enterprise-wide data tools in FY 2018.

Retired (changed to "legacy"): Performance Goal 3.3.7: Increase the adoption of technologies and services such as cloud computing throughout NASA's infrastructure and mission, leveraging savings from solutions such as reduced capital expenditures from not owning hardware, benefits from new technology capabilities, and increased computing flexibility available with "pay as you go" services.

Removed: AMO-18-21: Complete analysis and restructuring of NASA's IT portfolio in FY 2018.
Removed: AMO-18-22: Identify $50 million of NASA-wide cost avoidance and cost savings by the end of FY 2018.

Changed: Performance Goal 4.6.3: Between 2018 and 2019, demonstrate increased facility reliability by reducing spending on unscheduled maintenance by one percent annually.

Changed: AMO-18-8: Reduce spending on unscheduled maintenance (out of total maintenance spending) by at least one percentage point.

The following list shows the performance measures that have been removed for FY 2018, but which do not trend to the framework in NASA's *2018 Strategic Plan*. The performance goal numbers shown below are based on the framework in NASA's *2014 Strategic Plan*.

Removed: Performance Goal 1.1.3: Deliver two flight instruments that address critical environmental control and life support technology gaps.

Removed: Performance Goal 1.1.4: Launch three deep-space six-unit (6U) CubeSats on Exploration Mission-1.

Removed: ERD-18-3: Deliver three Advanced Exploration Systems (AES)-sponsored six-unit (6U) CubeSats for integration into the Exploration Mission (EM)-1 flight.

Image Captions and Credits

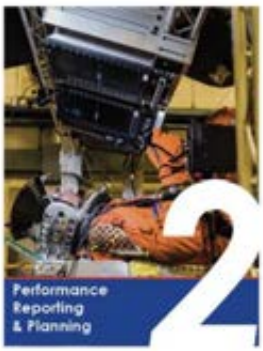
Cover Page

Image	Page	Description	Link
	0	On the cover, made from seven frames, the International Space Station (ISS) is seen transiting the solar eclipse at roughly five miles per second. Above the Sun, the faint image of an American flag aims upwards to mark the recent change in National space policy that provides for a U.S.-led, integrated program with private sector partners for a human return to the Moon, followed by missions to Mars and beyond. Image Credit: NASA/Joel Kowsky	https://www.nasa.gov/image-feature/iss-transit-during-2017-solar-eclipse

Part 1

Image	Page	Description	Link
	1	NASA's James Webb Space Telescope sits in Chamber A at NASA's Johnson Space Center in Houston, awaiting the colossal door to close. Image Credit: NASA/Chris Gunn	https://www.nasa.gov/feature/goddard/2017/nasa-webb-telescope-summertime-deep-freeze-continues

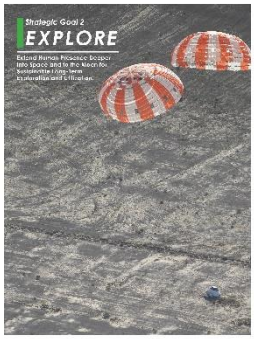
Part 2

Image	Page	Description	Link
	20	NASA engineers simulate conditions atop the Space Launch System (SLS) rocket while wearing modified advanced crew escape suits. Image Credit: NASA/Rad Sinyak	https://www.nasa.gov/image-feature/nasa-simulates-orion-spacecraft-launch-conditions-for-crew

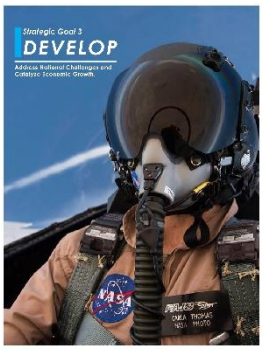
Strategic Goal 1

Image	Page	Description	Link
	27	The Geostationary Operational Environmental Satellite (GOES)-16 is a collaboration between NASA and the National Oceanic and Atmospheric Administration satellite GOES-16, captured this geocolor image of Hurricane Irma passing the eastern end of Cuba at about 8:00 a.m. EDT on September 8, 2017. Image Credit: NOAA/CIRA	https://www.nasa.gov/image-feature/geocolor-image-of-hurricane-irma
	29	The James Webb Space Telescope will be the premier observatory of the next decade, serving thousands of astronomers worldwide. Image Credit: NASA	https://www.nasa.gov/mission_pages/webb/about/index.html
	94	NASA astronaut Mark Vande Hei exits the ISS on October 10, 2017, for a spacewalk in this photograph, taken by fellow spacewalker Randy Bresnik. Image Credit: NASA	https://www.nasa.gov/image-feature/glorious-sunrise-at-the-start-of-a-spacewalk

Strategic Goal 2

Image	Page	Description	Link
	99	Orion's three main orange and white parachutes help a representative model of the spacecraft descend through sky above Arizona, where NASA engineers tested the parachute system on September 13, 2017, at the U.S. Army Proving Ground in Yuma. NASA is qualifying Orion's parachutes for missions with astronauts. *Image Credit: NASA/James Blair*	https://www.nasa.gov/image-feature/orion-parachutes-measure-up-in-high-pressure-test
	101	NASA astronaut Joe Acaba prepared the Veggie Facility for three different kinds of lettuce seeds as part of the VEG-03-D investigation. Image Credit: NASA	https://www.nasa.gov/image-feature/its-planting-season-on-the-international-space-station
	109	From a record breaking 18,300 applicants, NASA selected 12 new astronaut candidates to train for a variety of missions, including deep space missions on NASA's new Orion spacecraft and Space Launch System (SLS) rocket. Image Credit: NASA/Rob Markowitz	https://www.nasa.gov/press-release/nasa-s-newest-astronaut-recruits-to-conduct-research-off-the-earth-for-the-earth-and

Strategic Goal 3

Image	Page	Description	Link
	125	Sonic Booms in Atmospheric Turbulence, or SonicBAT, flights were performed at NASA's Armstrong Flight Research Center in Edwards, CA, in order to help NASA researchers measure the effect of low-altitude turbulence on sonic booms reaching the ground. Image Credit: NASA/Carla Thomas	https://www.nasa.gov/image-feature/photographer-carla-thomas-on-a-supersonic-flight
	127	Dr. Peter Peterson, an engineer at NASA Glenn Research Center, prepares a high-power solar electric propulsion thruster, a critical part of NASA's future deep space exploration plans. Image credit: NASA/Bridget Caswell/Alcyon Technical Services	https://www.nasa.gov/image-feature/electric-propulsion-will-thrust-exploration-into-deep-space
	140	The design studies for the Low Boom Flight Demonstration X-plane (concept image shown) are a first step towards supersonic overland flight and the possible return of quieter and more affordable supersonic passenger travel. Image Credit: NASA	https://www.nasa.gov/aeroresearch/programs/aavp/cst/technical-challenges
	157	At NASA's Kennedy Space Center, university students examine research equipment for the X-Hab (eXploration Systems and Habitation) Challenge to keep humans healthy and productive in deep space. Image Credit: NASA/Glenn Benson	https://www.nasa.gov/feature/students-help-solve-space-farming-challenges

Strategic Goal 4

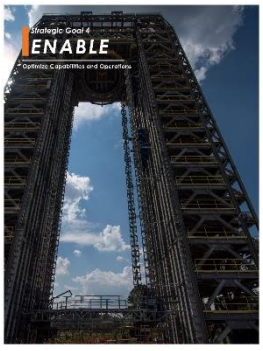
Image	Page	Description	Link
	174	The 215-foot-tall structural test stand for NASA's SLS is seen on September 24, 2017, at Marshall Space Flight Center in Huntsville, AL. NASA completed construction on the test stand in January 2017. Image Credit: NASA/Bill Ingalls	https://www.nasa.gov/centers/marshall/news/news/releases/2017/construction-complete-stand-prepares-to-test-sls-s-largest-fuel-tank.html
	176	The European Service Module, built by the European Space Agency, was tested at the NASA Glenn Research Center's Space Power Facility. It will supply Orion with electricity, propulsion, thermal control, air, and water. Image Credit: NASA	https://www.nasa.gov/feature/orion-s-power-system-to-be-put-to-the-test/

Image	Page	Description	Link
	188	NASA's Commercial Crew Program is an innovative partnership with the American aerospace industry to develop space transportation systems to safely launch humans to low Earth orbit and the ISS. Image Credit: NASA	https://www.nasa.gov/content/boeing-spacex-race-to-station
	206	In the Gulf of Mexico, astronauts practice exit procedures from NASA's Orion spacecraft in preparation for their future journeys to destinations beyond the Moon. Image Credit: NASA/Josh Valcarcel	https://www.nasa.gov/image-feature/nasa-evaluates-how-crew-will-exit-orion-spacecraft
	214	One hundred years ago, the United States established the first civilian laboratory dedicated to unlocking the mysteries of flight. Since then, the NASA Langley Research Center has continued a rich heritage of aeronautical innovation. Image Credit: NASA	https://www.nasa.gov/langley/feature/nasa-langley-sets-the-stage-for-2017-centennial-celebration
	224	NASA astronaut Reid Wiseman, Expedition 40 flight engineer, wearing a communication headset, participates in an International Space Station (ISS) Ham Radio session. Image Credit: NASA	https://www.nasa.gov/mission_pages/station/research/experiments/346.html
	239	Looking up in High Bay 3 at NASA's Kennedy Space Center, workers at the Vehicle Assembly Building completed the removal of old shuttle hardware and installation of 10 levels of large work platforms that will allow the stacking of the SLS. Image Credit: NASA/Frank Michaux	https://www.nasa.gov/feature/final-work-platform-installed-in-vehicle-assembly-building-for-nasas-space-launch-system

Part 3

Image	Page	Description	Link
	248	High up in the transfer aisle of the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida, a crane turns the final work platform, A North, for transfer into High Bay 3. The A-level platforms will provide access to the Orion spacecraft's Launch Abort System for Orion lifting sling removal and installation of the closeout panels. Image Credit: NASA/Frank Michaux	https://images.nasa.gov/details-KSC-20170112-PH_FWM01_0241.html

End Page

Image	Page	Description	Link
	Back Cover	On June 14, 2015, the ISS Expedition 44 crew prepare to observe U.S. Flag Day in the Cupola Observational Module, the 360-degree observation window. Image Credit: NASA	https://www.nasa.gov/image-feature/us-flag-in-the-cupola

National Aeronautics and Space Administration

NASA Headquarters
300 E Street, SW
Washington, DC 20546
www.nasa.gov/centers/hq
www.nasa.gov