Part 3

FY 2014
Annual Performance Report

FY 2016
Annual Performance Plan

Introduction

Part 3 presents NASA's integrated FY 2014 Annual Performance Report, FY 2015 Annual Performance Plan Update, and FY 2016 Annual Performance Plan. It features a summary of NASA's first-ever Strategic Review by strategic objective, with strategic objective-level performance ratings selected by NASA in consultation with the Office of Management and Budget (OMB). It also shows up to six years of historical rated performance alongside two years of future plans. Together this information provides a retrospective and prospective view of NASA's performance.

The integrated report contains the following:

- Charts summarizing performance goal and annual performance indicator ratings, organized by strategic goal.
- A summary of the annual Strategic Review by strategic objective. The section below provides an overview of the strategic objective content.
- The strategic objective's budget, actuals from FY 2014, the budget request for FY 2016, and notional funding through FY 2020.
- The performance goals contributing to the strategic objective. Each performance goal includes an FY 2014 performance rating, multiyear performance trends beginning with FY 2011,[3] any planned performance changes for FY 2015 or FY 2016, a narrative describing activities contributing to performance progress in FY 2014, and an improvement plan for performance goals rated yellow or red. Figure 15 is a quick guide to the performance tables.
- The annual performance indicators associated with the performance goal, including the FY 2014 performance rating, multiyear performance trends beginning with FY 2009, the planned performance for FY 2015 and FY 2016, and a performance explanation for annual performance indicators rated yellow or red.

NASA's method for trending multiyear performance data is to show the linkages between measures tracking similar data and annual progress for follow-on program activities. Linked measures, even if revised in subsequent years, are shown as related performance data. In some cases, measures have been updated over the years to improve accuracy and data quality.

[3]NASA introduced performance goals with its 2011 Strategic Plan and, therefore, the performance goals only trend back to FY 2011. NASA has had annual measures since the 2003 Strategic Plan and presents actual results for up to six years. Additional years of actual results are maintained in NASA's performance data system.

How to Read the Strategic Objective Information

The information presented below the strategic objectives is the result of NASA's first Strategic Review, completed in spring 2014 in accordance with OMB guidance. In addition, supporting performance goals and annual performance indicators are provided in a table for each strategic objective.

Budget

Each strategic objective consists of Contributing Programs. NASA provides the budget authority for these programs in its annual Congressional Justification, available at http://www.nasa.gov/news/budget/index.html. Through this budget–performance crosswalk NASA is able to estimate a budget for each strategic objective.

	Actual	Enacted	Requested	Notional			
Budget Authority (in $ millions)	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$xxxx	-----	$xxxx	$xxxx	$xxxx	$xxxx	$xxxx

- The budget totals provided in the table above consist of a summation of the budget authority for each program that contributes to the strategic objective. These programs are provided under the "Contributing Program" header for each strategic objective. The source for the budget data is NASA's FY 2016 Budget Estimates.
- FY 2014 reflects funding amounts specified in the June 2014 Operating Plan per P.L. 113-76.
- Totals for FY 2015 are not available at this time; the initial operating plan is not yet approved.
- Note that totals of all budgets provided for strategic objectives will not add to the NASA total budget request; funds associated with the Inspector General do not map to specific strategic objectives and are not included in any strategic objective budget roll-up.

Strategic Review Assessment Rating

A subset of strategic objectives are to be identified as achieving noteworthy progress or as a focus area for improvement. The "Update of Progress Toward Strategic Objective" section will note if NASA, in consultation with OMB, assessed the strategic objective as making noteworthy progress or as a focus are for improvement. If the section does not provide a rating, it means that NASA found that the strategic objective is demonstrating satisfactory performance.

How to Read the Performance Goal and Annual Performance Indicator Information

Performance Goal Table and Fiscal Year Results

For each performance goal, NASA provides a table of information summarizing both results and plans. OMB Circular A-11 requires agencies to provide six years of trended ratings, including the reporting fiscal year. NASA introduced performance goals in its 2011 Strategic Plan and, therefore, can only provide up to four years of ratings. Each table also includes "Planned Future Performance" for FY 2015 and FY 2016. The table will note if the performance goal does not continue beyond FY 2014. If NASA is introducing the performance goal in FY 2015 or FY 2016, the performance goal language will be provided in the "Planned Future Performance" field, the FY 2014 rating field will be "None," and the FY 2011 through FY 2013 rating fields will be "No PG this fiscal year."

The table also indicates the "Contributing Theme" and "Contributing Program" responsible for pursuing activities as described in the performance goal.

The "FY 2014 Performance Results" summarizes the work related to the performance goal. It includes a performance improvement plan for performance goals rated yellow or red.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Achieve critical milestones in development of new systems for the human exploration of deep space. (Agency Priority Goal)	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.1.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Exploration Systems Development	**Contributing Program:** Multiple Programs			

Annual Performance Indicator Table

The annual performance indicator tables follow the same format as those for the performance goals, except that they trend to FY 2009. NASA does not summarize the performance results for the annual performance indicators; however, it provides an "Explanation of Rating" for annual performance indicators rated yellow or red.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the Critical Design Review (CDR) of the Space Launch System (SLS) Core Stage.	No API this fiscal year	No API this fiscal year	HEC-11-1 Green	ESD-12-1 Green	ESD-13-1 Green	ESD-14-1 Green
Planned Future Performance						
For FY 2015: ESD-15-1: Complete the Space Launch System (SLS) Critical Design Review (CDR) in support of Key Decision Point D.						
For FY 2016: ESD-16-1: Conduct the second of two Space Launch System (SLS) booster qualification motor test firings (QM-2).						
Contributing Theme: Exploration Systems Development	**Contributing Program:** Space Launch System					

7
Strategic
Objectives

Strategic Goal 1

Expand the frontiers of knowledge, capability, and opportunity in space.

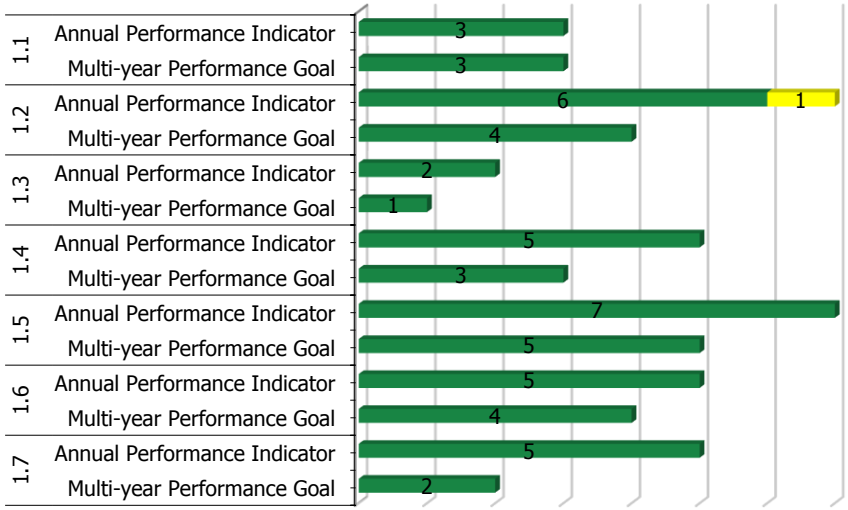
30
Performance
Goals

51
Annual
Performance
Indicators

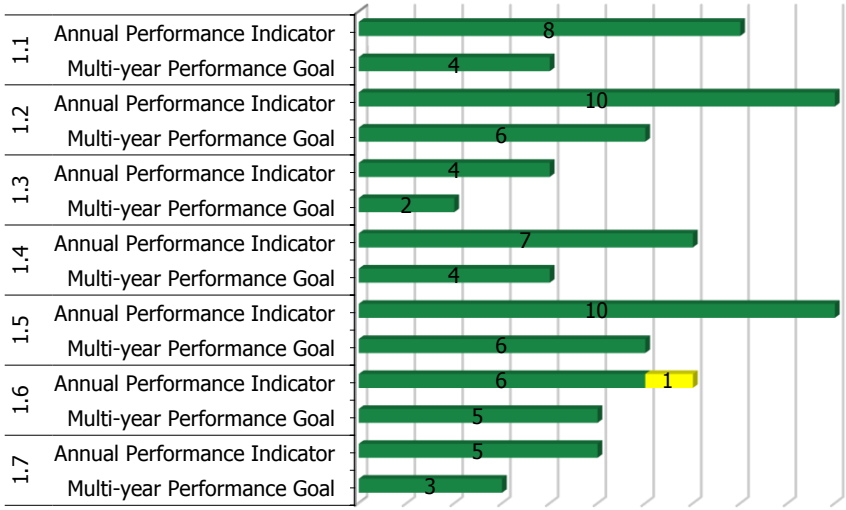
Strategic Goal 1: Expand the frontiers of knowledge, capability, and opportunity in space.						
Strategic Objective 1.1: Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.	Strategic Objective 1.2: Conduct research on the International Space Station (ISS) to enable future space exploration, facilitate a commercial space economy, and advance the fundamental biological and physical sciences for the benefit of humanity.	Strategic Objective 1.3: Facilitate and utilize U.S. commercial capabilities to deliver cargo and crew to space.	Strategic Objective 1.4: Understand the Sun and its interactions with Earth and the solar system, including space weather.	Strategic Objective 1.5: Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.	Strategic Objective 1.6: Discover how the universe works, explore how it began and evolved, and search for life on planets around other stars.	Strategic Objective 1.7: Transform NASA missions and advance the Nation's capabilities by maturing crosscutting and innovative space technologies.
FY 2014 Performance Goals						
• 1.1.1: Achieve critical milestones in development of new systems for the human exploration of deep space. (Agency Priority Goal) • 1.1.2: Complete System Requirements Reviews by FY 2015 for the In-Situ Resource Utilization Demonstration Experiment on the Mars 2020 mission. • 1.1.3: Develop technologies to enable autonomous mission operations in space to increase affordability. • 1.1.4: Mature environmental control and life support system (ECLSS) technology to enable human exploration beyond low Earth orbit.	• 1.2.1: Increase utilization of the International Space Station's internal and external research facilities. (Agency Priority Goal) • 1.2.2: Maintain capability for six on-orbit crew members. • 1.2.3: Advance engineering, technology, and science research. • 1.2.4: Ensure vital assets are ready, available, and appropriately sized to conduct NASA's Mission. • 1.2.5: Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise. • 1.2.6: Provide cargo transportation to support on-orbit crew members and utilization.	• 1.3.1: Facilitate the development of and certify U.S. industry-based crew transportation systems while maintaining competition. (Agency Priority Goal) • 1.3.2: Invest financial and technical resources to stimulate efforts within the private sector to develop and demonstrate safe, reliable, and cost-effective space transportation capabilities.	• 1.4.1: Demonstrate progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system. • 1.4.2: 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. • 1.4.3: 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. • 1.4.4: By December 2017, launch two missions in support of Strategic Objective 1.4.	• 1.5.1: Demonstrate progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact and evolve. • 1.5.2: Demonstrate progress in exploring and observing the objects in the solar system to understand how they formed and evolve. • 1.5.3: Demonstrate progress in exploring and finding locations where life could have existed or could exist today. • 1.5.4: Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere. • 1.5.5: Demonstrate progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration. • 1.5.6: By December 2017, launch at least two missions in support of Strategic Objective 1.5.	• 1.6.1: Launch the James Webb Space Telescope. (Agency Priority Goal) • 1.6.2: Demonstrate progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity. • 1.6.3: Demonstrate progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe. • 1.6.4: Demonstrate progress in discovering and studying planets around other stars and exploring whether they could harbor life. • 1.6.5: By December 2018, launch at least one mission in support of Strategic Objective 1.6.	• 1.7.1: Explore and advance promising early stage solutions to space technology challenges through investment across the U.S. innovation community. • 1.7.2: Advance technologies that offer significant improvement to existing solutions or enable new space science and exploration capabilities. • 1.7.3: Mature new crosscutting space technology capabilities for demonstration.

Summary of Performance for Strategic Goal 1

Comparison of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2013



Comparison of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2014



Summary of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2013

Strategic Goal 1			
Lead	**Objective**	**PGs**	**APIs**
HEOMD	1.1	3	3
HEOMD	1.2	4	6 / 1
HEOMD	1.3	1	2
SMD	1.4	3	5
SMD	1.5	5	7
SMD	1.6	4	5
STMD	1.7	2	5
	Total	22	34
	Summary	100% Green	97% Green
			3% Yellow

Summary of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2014

Strategic Goal 1			
Lead	**Objective**	**PGs**	**APIs**
HEOMD	1.1	4	8
HEOMD	1.2	6	10
HEOMD	1.3	2	4
SMD	1.4	4	7
SMD	1.5	6	10
SMD	1.6	5	6 / 1
STMD	1.7	3	5
	Total	30	51
	Summary	100% Green	98% Green
			2% Yellow

Strategic Objective 1.1

Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.

Lead Office
Human Exploration and Operations Mission Directorate (HEOMD)

Goal Leader
Greg Williams, Deputy for Policy and Management, HEOMD

Contributing Programs
Advanced Exploration Systems (AES), Exploration Ground Systems (EGS), Orion Multi-Purpose Crew Vehicle, Space Launch System (SLS)

Budget for Strategic Objective 1.1

Budget Authority (in $ millions)	Actual FY 2014	Enacted FY 2015	Requested FY 2016	Notional FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$3,268	---	$3,094	$3,127	$3,389	$3,913	$4,024

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
In 10 years, NASA will have a new human deep-space exploration architecture with SLS, Orion, and other high-priority capabilities needed for human exploration and pioneering.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- HEOMD is implementing an iterative, strategic approach to prioritize activities that support human exploration beyond low Earth orbit.
- Strategies are demonstrating success in achieving the strategic objective, including the agency priority goal. HEOMD is progressing well towards completion of near-term Program milestones with no schedule slips.
- SLS, Orion, and EGS are currently making satisfactory progress toward Exploration Mission (EM)-1, and while there may be technical challenges in the out-years, the programs continue to meet their milestones.
- Challenges include: Schedule and cost pressures; and development of the human systems needed to execute the Asteroid Redirect Mission.

FY 2014 achievements include the following:

- Completing the Critical Design Review (CDR) for the SLS core stage.
- Completing Orion manufacturing and assembly, in preparation for Exploration Flight Test (EFT)-1.
- Completing the EGS Preliminary Design Review (PDR).
- Successfully demonstrating an autonomous flight demonstration of the Autonomous Landing and Hazard Avoidance Technology (ALHAT) hazard detection and avoidance and precision landing system on the Morpheus vehicle test bed.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

NASA is on track to achieve the agency priority goal to "complete the Space Launch System, Orion, and Exploration Ground Systems CDRs, allowing the programs to continue to progress toward Exploration Mission (EM)-1 and EM-2 missions" by September 2015.

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

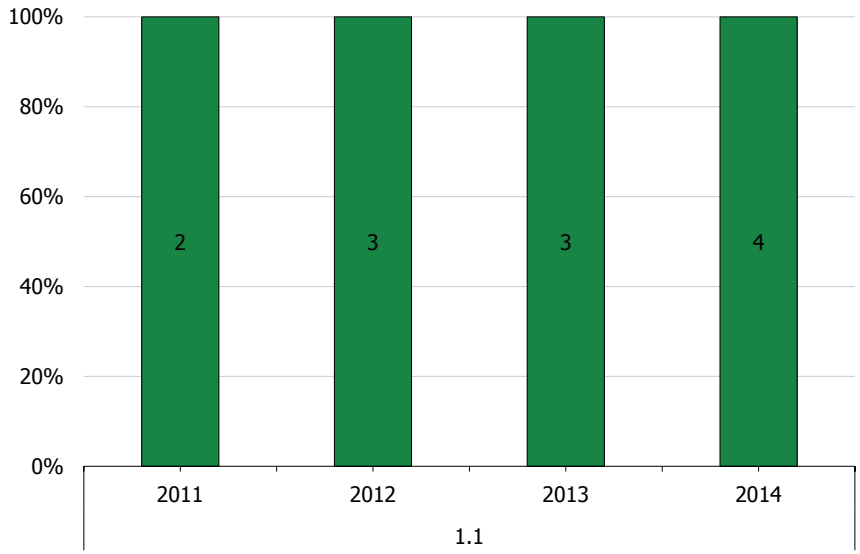
Next Steps in FY 2015

- Complete Critical Design Reviews for both SLS and EGS.
- Continue to plan for an Asteroid Redirect Mission to visit an asteroid mass placed in lunar orbit.

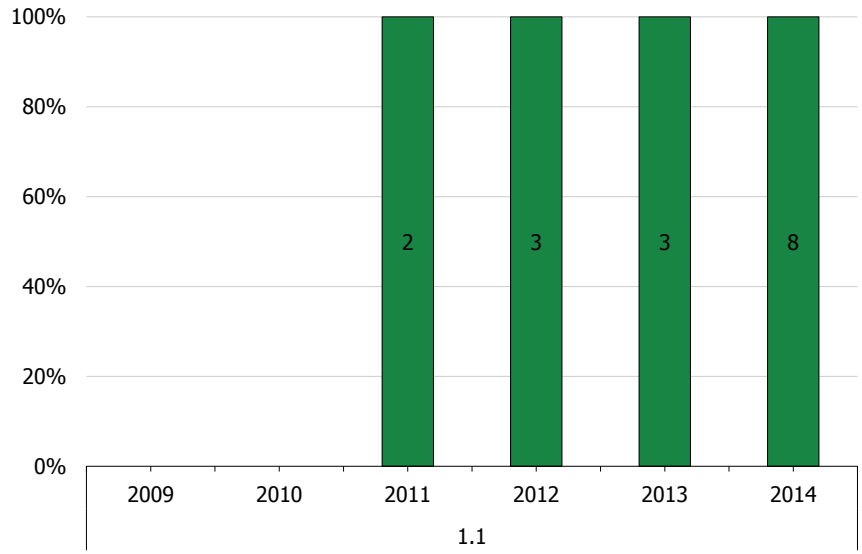
FY 2014 Performance Measures

Strategic Objective 1.1: Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.			
Performance Goal 1.1.1: Achieve critical milestones in development of new systems for the human exploration of deep space. (Agency Priority Goal)	Performance Goal 1.1.2: Complete System Requirements Reviews by FY 2015 for the In-Situ Resource Utilization Demonstration Experiment on the Mars 2020 mission.	Performance Goal 1.1.3: Develop technologies to enable autonomous mission operations in space to increase affordability.	Performance Goal 1.1.4: Mature environmental control and life support system (ECLSS) technology to enable human exploration beyond low Earth orbit.
Annual Performance Indicators			
• ESD-14-1: Complete the Critical Design Review (CDR) of the Space Launch System (SLS) Core Stage. • ESD-14-2: Complete Orion manufacturing and assembly so the spacecraft is ready for launch vehicle integration for the Exploration Flight Test 1 (EFT-1). • ESD-14-3: Complete the Exploration Ground Systems Program Preliminary Design Review (PDR).	• ERD-14-2: Complete International Lander contribution assessments for the robotic precursor mission. • ERD-14-3: Award contracts to industry to fabricate and test several proof of concept asteroid capture mechanisms. • ERD-14-6: Define the payload concept for the In-Situ Resource Utilization Demonstration Experiment on Mars 2020 mission.	• ERD-14-4: Test Autonomous Mission Operations software for the International Space Station to reduce crew's dependence on ground-based mission control.	• ERD-14-5: Conduct integrated subsystem tests for improved water recovery and more reliable atmosphere revitalization systems.

Performance Goal Ratings for Strategic Objective 1.1, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 1.1, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Achieve critical milestones in development of new systems for the human exploration of deep space. (Agency Priority Goal)	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.1.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Exploration Systems Development	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

In FY 2014, NASA made significant progress towards achieving this agency priority goal, and is on track to complete it in FY 2015. NASA is developing the Nation's first human deep-space exploration capability with the Space Launch System (SLS) and the Orion crew vehicle. With the support of the Exploration Ground Systems Program, SLS and Orion will carry humans farther into space than ever before.

In July 2014, NASA completed the SLS core stage Critical Design Review (CDR). The CDR is a significant review that demonstrates that the design of the SLS is mature enough for production. NASA also signed the SLS Key Decision Point (KDP)-C memorandum on August 26, 2014. The KDP-C review is an assessment of a project's readiness to move from formulation into full-scale development. The memorandum documents that the project has met all of the KDP-C criteria.

During FY 2014, NASA prepared for the Orion Exploration Flight Test (EFT)-1, which launched an uncrewed Orion flight test vehicle to approximately 3,600 feet to test critical vehicle systems. NASA completed initial power-on tests and functional tests of the Orion test vehicle, as well as test vehicle manufacturing and assembly. On September 7, 2014, NASA delivered the completed Orion crew service module to ground processing on its way to the Space Launch Complex-37 launch pad. The crew service module is a primary component of the Orion EFT-1 spacecraft. In FY 2015, on December 5, 2014, EFT-1 completed its uncrewed test and was recovered successfully.

In March 2014, NASA completed the Preliminary Design Review (PDR) for the Ground Systems Development and Operations (GSDO) Program. The PDR ensures that the designs and systems selected are appropriate to the program's needs, that the risks have been assessed, and that the estimated cost and schedule baselines are acceptable. The GSDO Program's mission is to prepare the Kennedy Space Center to process and launch the next generation of rockets and spacecraft in support of NASA's exploration objectives by developing the necessary ground systems, infrastructure, and operational approaches. The GSDO PDR validated that the ground systems designs were on track to process and launch the SLS and Orion from the Kennedy Space Center. In addition, NASA signed the GSDO KDP-C memorandum on September 9, 2014.

More detailed information on this agency priority goal is included in Part 2 of this document.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the Critical Design Review (CDR) of the Space Launch System (SLS) Core Stage.	No API this fiscal year	No API this fiscal year	HEC-11-1 Green	ESD-12-1 Green	ESD-13-1 Green	ESD-14-1 Green
Planned Future Performance						
For FY 2015: ESD-15-1: Complete the Space Launch System (SLS) Critical Design Review (CDR) in support of Key Decision Point D.						
For FY 2016: ESD-16-1: Conduct the second of two Space Launch System (SLS) booster qualification motor test firings (QM-2).						
Contributing Theme: Exploration Systems Development	**Contributing Program:** Space Launch System					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete Orion manufacturing and assembly so the spacecraft is ready for launch vehicle integration for the Exploration Flight Test 1 (EFT-1).	No API this fiscal year	No API this fiscal year	HEC-11-2 Green	ESD-12-2 Green	ESD-13-2 Green	ESD-14-2 Green
Planned Future Performance						
For FY 2015: ESD-15-2: Complete Orion Key Decision Point-C.						
For FY 2016: ESD-16-2: Begin assembly and integration of the Orion Exploration Mission-1 flight article in the Armstrong Operations and Checkout Building at the Kennedy Space Center.						
Contributing Theme: Exploration Systems Development	**Contributing Program:** Orion Multi-Purpose Crew Vehicle					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the Exploration Ground Systems Program Preliminary Design Review (PDR).	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ESD-14-3 Green
Planned Future Performance						
For FY 2015: ESD-15-3: Complete the Exploration Ground Systems Program Critical Design Review (CDR).						
For FY 2016: ESD-16-3: Complete the Exploration Ground Systems Program System Integration Review (SIR).						
Contributing Theme: Exploration Systems Development	**Contributing Program:** Exploration Ground Systems					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Complete System Requirements Reviews by FY 2015 for the In-Situ Resource Utilization Demonstration Experiment on the Mars 2020 mission.	No PG this fiscal year	1.3.3.1 Green	1.3.3.1 Green	1.1.2 Green
Planned Future Performance				
For FY 2015: Complete the Systems Requirements Review by FY 2015 for the In-Situ Resource Utilization Demonstration Experiment on Mars 2020.				
For FY 2016: Complete Design Reviews for planetary In-Situ Resource Utilization Demonstrations.				
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems			

FY 2014 Performance Results

NASA's Advanced Exploration Systems (AES) Program is pioneering new approaches to develop prototype systems, demonstrate key capabilities, and validate operational concepts for future human missions beyond Earth orbit. The AES Program focuses on crew safety and mission operations in deep

space. 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 mission will provide opportunities to gather knowledge and demonstrate technologies, such as in-situ resource utilization (ISRU). The AES Program, in collaboration with NASA's Space Technology Mission Directorate (STMD), plans to deploy a carbon dioxide capture, storage, and oxygen-processing payload to demonstrate the value of ISRU in reducing mission cost and risk for future human missions. On July 30, 2014, NASA selected the Massachusetts Institute of Technology-led Mars Oxygen ISRU Experiment (MOXIE) as a payload for the Mars 2020 mission. MOXIE will be co-funded by the AES Program and STMD.

In addition, NASA is proposing an Asteroid Redirect Mission to divert a local asteroid into an accessible orbit. Through this mission, NASA will make strides in technical capabilities, such as solar electric propulsion and capture mechanisms, which will enable operations in human space explorations missions.

In July 2014, NASA awarded four contracts to industry to fabricate and test proof-of-concept asteroid capture mechanisms:

- Airborne Systems North America in Santa Ana, CA—The "Asteroid Capture System" study will fabricate and test a proof-of-concept inflatable capture system.
- Jacobs in Houston, TX—The "Asteroid Capture System Conceptual Study" will test a subscale capture system using mechanically deployed booms.
- Altius Space Machines in Louisville, CO—The "Kraken Asteroid Boulder Retrieval System" will test prototype grasping arms and gripper concepts for capturing a boulder off the surface of an asteroid.
- Space Systems/Loral in Palo Alto, CA—The "Autonomous Boulder Liberation Equipment" study will demonstrate robotic arms for placement and handling of pneumatic excavation tools, boulder jacking devices, and positive capture and restraint tools.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete International Lander contribution assessments for the robotic precursor mission.	No API this fiscal year	No API this fiscal year	No API this fiscal year	ERD-12-4 Green	ERD-13-2 Green	ERD-14-2 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Award contracts to industry to fabricate and test several proof of concept asteroid capture mechanisms.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ERD-14-3 Green
Planned Future Performance						
For FY 2015: ERD-15-2: Down-select asteroid capture system for the Asteroid Redirect Mission (ARM).						
For FY 2016: No API this fiscal year						
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Define the payload concept for the In-Situ Resource Utilization Demonstration Experiment on Mars 2020 mission.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ERD-14-6 Green
Planned Future Performance						
For FY 2015: ERD-15-3: Complete the Systems Requirements Review (SRR) for the In-Situ Resource Utilization Demonstration Experiment on Mars 2020 mission.						
For FY 2016: ERD-16-2: Complete the Critical Design Review (CDR) for the In-Situ Resource Utilization Demonstration Experiment on the Mars 2020 mission.						
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Develop technologies to enable autonomous mission operations in space to increase affordability.	3.3.1.1 Green	3.3.1.1 Green	3.3.1.1 Green	1.1.3 Green
Planned Future Performance				
This performance goal does not continue past FY 2014.				
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems			

FY 2014 Performance Results

NASA's Advanced Exploration Systems (AES) Program is developing revolutionary new approaches to further automate mission operations. When humans explore near-Earth objects, Mars, and other destinations deep in space, astronauts and flight controllers no longer will be able to relay messages and commands back and forth in a matter of seconds. By the time word gets back to mission control, the crew may need to already be working on a solution to an anomaly or performing operations independently during a time-critical mission phase. The AES Program is working to reduce crew dependence on ground-based mission control by automating flight dynamics and consumables management on the International Space Station (ISS).

During FY 2014, NASA integrated autonomous mission operations software onto the Total Organic Carbon Analyzer (TOCA) hardware onboard the ISS. The TOCA is used to ensure that reclaimed water aboard the ISS is safe to drink. The ISS crew first used the autonomous mission operations software on September 5, 2014. The crew is using the software to optimize the operation of the TOCA hardware and test the fidelity of the software. Each week, the onboard crew uses autonomous mission operations software to provide a recommendation of what TOCA activities are required for the next planning cycle. The experiment is designed to integrate with established ground analyses and planning cycles to reduce the risk to the crew and equipment.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Test Autonomous Mission Operations software for the International Space Station to reduce crew's dependence on ground-based mission control.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ERD-14-4 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Mature environmental control and life support system (ECLSS) technology to enable human exploration beyond low Earth orbit.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.1.4 Green
Planned Future Performance				
This performance goal does not continue past FY 2014.				
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems			

FY 2014 Performance Results

NASA's Advanced Exploration Systems (AES) Program is developing capabilities to provide a safe environment for astronauts and minimize the resupply burden of deep space habitats. As NASA prepares 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, it is developing and testing life-support systems to make those journeys possible. The AES Program is improving the reliability of water recycling, air revitalization, and environmental monitoring systems of life-support systems using ground test beds.

In FY 2014, the AES Program tested improvements to the water recovery and atmosphere revitalization components of the Environmental Control and Life Support System (ECLSS) aboard the International Space Station (ISS). The ECLSS is designed to:

- Provide oxygen for metabolic consumption;
- Provide potable water for consumption, food preparation, and hygienic uses;
- Filter or remove carbon dioxide, particulates and microorganisms, and volatile organic trace gases from the cabin air;
- Monitor and control cabin air partial pressures of nitrogen, oxygen, carbon dioxide, methane, hydrogen, and water vapor;
- Maintain total cabin pressure, cabin temperature, and humidity levels; and
- Distribute cabin air between connected modules.

NASA used the Cascade Distillation System (CDS), a rotary distillation system with the potential for greater reliability and lower energy costs than existing distillation systems, to treat wastewater streams with different pre-treatment regimens, producing purified water at 85 percent process efficiency. NASA also completed integrated chamber testing of ISS-derived atmosphere revitalization systems and demonstrated that they have reduced mass and improved reliability compared to the systems currently in use aboard the ISS.

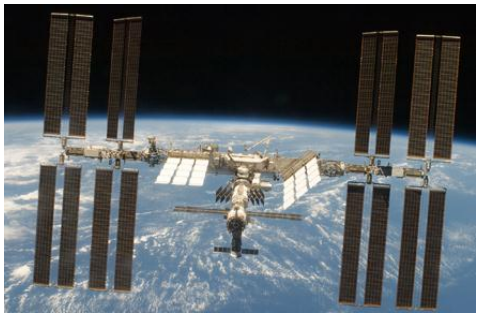
Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Conduct integrated subsystem tests for improved water recovery and more reliable atmosphere revitalization systems.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ERD-14-5 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Does not trend to FY 2014.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	None
Planned Future Performance				
For FY 2015 and FY 2016: 1.1.5: Incorporate autonomous controls in life support subsystems testing to increase reliability.				
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems			

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: ERD-15-4: Integrate sensors and feedback controls with the air-revitalization subsystem to increase system performance.						
For FY 2016: ERD-16-4: Analyze the performance of sensors, controls, and multiple life-support system components in integrated tests.						
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Does not trend to FY 2014.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	None
Planned Future Performance				
For FY 2015: No performance goal this fiscal year				
For FY 2016: 1.1.6: Demonstrate systems concepts and technology for the Asteroid Redirect Mission (ARM).				
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems			

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: ERD-16-3: Demonstrate spacesuits and operational concepts for asteroid extravehicular activity (EVA).						
Contributing Theme: Exploration Research and Development	**Contributing Program:** Advanced Exploration Systems					



Strategic Objective 1.2

Conduct research on the International Space Station (ISS) to enable future space exploration, facilitate a commercial space economy, and advance the fundamental biological and physical sciences for the benefit of humanity.

Lead Office
Human Exploration and Operations Mission Directorate (HEOMD)

Goal Leader
Greg Williams, Deputy for Policy and Management, HEOMD

Contributing Programs
Human Research, Human Space Flight Operations, International Space Station

Budget for Strategic Objective 1.2

Budget Authority (in $ millions)	Actual FY 2014	Enacted FY 2015	Requested FY 2016	Notional FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$3,220	---	$3,382	$3,554	$3,930	$4,115	$4,330

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
NASA will advance benefits to humanity through research, enable a commercial demand-driven market in low Earth orbit, enable long-duration human spaceflight beyond low Earth orbit, and provide a basis for international exploration partnerships.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- The International Space Station (ISS) is the cornerstone of human exploration and operations. Both the life extension to 2024 and the commercial cargo successes facilitate increased availability of research opportunities.
- Strategies are demonstrating success in achieving the strategic objective.
- Challenges include: Utilizing ISS to its fullest capability; managing crew time as research demand grows; maintaining steady pace of resupply/return missions from commercial partners; and bringing commercial crew partners to a regular operational flight cadence.
- Opportunities include: A variety of new possible partnerships (commercial, interagency, international).

FY 2014 achievements included the following:

- The ISS achieved a milestone in early July 2014 of reaching 5,000 days of humans living and working aboard the station.
- Two U.S.-developed commercial cargo delivery systems successfully delivered research and logistics hardware to the ISS.
- Increased ISS facility occupancy and accomplished on-orbit research and technology development objectives. Utilization of the ISS broadened to capitalize on the external unpressurized capabilities of the station.
- The first Center for the Advancement of Science in Space (CASIS)-sponsored payloads were delivered to the ISS, successfully broadening space research on the national laboratory to include investigators outside the space community.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

The ISS Program and its International Partners have completed reviews to ensure that the on-orbit infrastructure is certified to safely operate the ISS through at least 2024. In addition, NASA is on track to achieve the agency priority goal to "increase the utilization of the International Space Station internal and external research facility sites with science and technology payload hardware to 70 percent" by September 2015. NASA will continue working towards the goal of increasing utilization of the ISS by expanding the availability of crew time for research through efficiencies, and through future augmentation to seven crew, planned with the arrival of commercial crew capability in 2017.

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

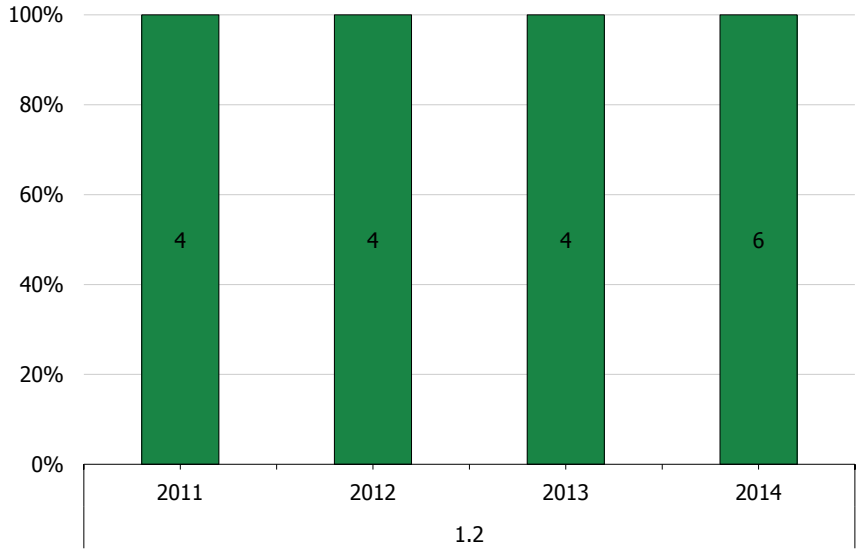
Next Steps in FY 2015

- Maintain a safe and functional on-orbit platform.
- Continue to expand the ISS on-orbit research program, including continuing to increase utilization of ISS internal and external research facilities.
- Continue the commercial and International Partner cargo missions to resupply the ISS.

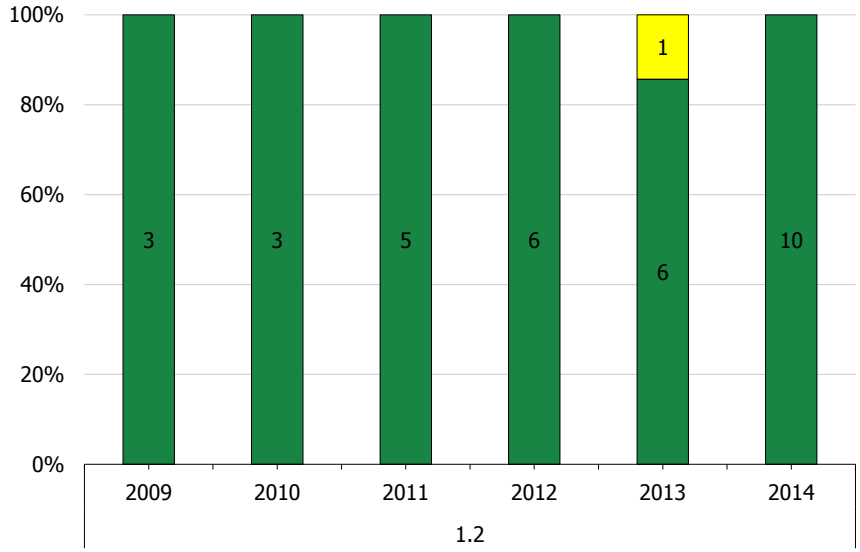
FY 2014 Performance Measures

Strategic Objective 1.2: Conduct research on the International Space Station (ISS) to enable future space exploration, facilitate a commercial space economy, and advance the fundamental biological and physical sciences for the benefit of humanity.					
Performance Goal 1.2.1: Increase utilization of the International Space Station's internal and external research facilities. (Agency Priority Goal)	Performance Goal 1.2.2: Maintain capability for six on-orbit crew members.	Performance Goal 1.2.3: Advance engineering, technology, and science research.	Performance Goal 1.2.4: Ensure vital assets are ready, available, and appropriately sized to conduct NASA's Mission.	Performance Goal 1.2.5: Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise.	Performance Goal 1.2.6: Provide cargo transportation to support on-orbit crew members and utilization.
Annual Performance Indicators					
• ISS-14-4: Increase facility occupancy beyond the FY 2013 baseline of 60 percent.	• ISS-14-1: In concert with International Partners, maintain a continuous six-crew capability on ISS by coordinating and managing resources, logistics, systems, and operational procedures.	• ERD-14-1: Complete two space radiation national research campaigns at the NASA Space Radiation Laboratory at Brookhaven National Laboratory. • ISS-14-3: Accomplish a minimum of 90 percent of the on-orbit research and technology development objectives.	• SFS-14-7: Appropriately size the astronaut corps to provide timely assignments based upon mission needs.	• ISS-14-5: Complete all pre-flight activities and be ready to support the launch of the first flight with animals. • ISS-14-6: Conduct successful Critical Design Reviews (CDR) for four physical science payloads and a Preliminary Design Review (PDR) for the Cold Atom Laboratory in FY 2014. • ISS-14-7: CASIS will release two Requests for Proposals, complete proposal evaluation, and select research projects for ISS execution in FY 2014. • ISS-14-8: Produce 450 peer-reviewed publications from projects in human research, space biology, and physical sciences.	• ISS-14-2: Complete at least three flights by U.S.-developed cargo delivery systems, delivering research and logistics hardware to ISS.

Performance Goal Ratings for Strategic Objective 1.2, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 1.2, FY 2009 through FY 2014



Past fiscal years do not include annual performance indicators that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Increase utilization of the International Space Station's internal and external research facilities. (Agency Priority Goal)	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.2.1 Green
Planned Future Performance				
This performance goal continues through FY 2015.				
Contributing Theme: International Space Station	**Contributing Program:** International Space Station			

FY 2014 Performance Results

In FY 2014, NASA made significant progress towards achieving this agency priority goal. The International Space Station (ISS) is on track to achieve its 70 percent occupancy goal (also referred to as facility utilization) by the end of FY 2015. NASA measures facility utilization by combining the occupancy of internal research facility sites, the occupancy of external research facilities, and the use of available duty cycles of operational facilities.

The ISS is a world-renowned laboratory that performs multidisciplinary research in science and technology. NASA is increasing the utilization of the ISS to conduct scientific research, for exploration-related technology development, and to foster commercial investment in space. Increasing facility utilization is a function of the demand for the use of 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 2014, the following research payloads were launched to the ISS:

- On January 7, 2014, Orbital Sciences Corporation's Orbital-1 launched with six CubeSats (i.e., miniaturized satellites for space research) and science resupply.
- On April 18, 2014, Space Exploration Technologies Corporation's (SpaceX's) SpaceX-3 launched with two unpressurized payloads to be placed on the exterior of the ISS, the High Definition Earth Viewing (HDEV) camera and the Optical PAyload for Lasercomm Science (OPALS).
- On July 12, 2014, Orbital-2 launched with more CubeSats and science resupply.
- On July 29, 2014, the European Space Agency's Automated Transfer Vehicle (ATV)-5 launched with two new facilities, a new handrail exposure facility and an electromagnetic levitator.
- On September 22, 2014, SpaceX-4 launched with the ISS-Rapid Scatterometer, designed to measure near-surface ocean wind speed and direction; new Rodent Research Hardware; and a three-dimensional printer, which is the first step towards establishing an on-demand machine shop in space.

NASA continues to make progress towards this agency priority goal in FY 2015. On January 10, 2015, SpaceX-5 was launched to the ISS. Its payload included the new Cloud-Aerosol Transport System (CATS) external payload to study the atmospheric constituents that impact Earth's climate.

More detailed information on this agency priority goal is included in Part 2 of this document.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Increase facility occupancy beyond the FY 2013 baseline of 60 percent.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ISS-13-4 Yellow	ISS-14-4 Green
Planned Future Performance						
For FY 2015: ISS-15-1: Continue to increase facility occupancy to 70 percent.						
For FY 2016: No API this fiscal year						
Contributing Theme: International Space Station	**Contributing Program:** International Space Station					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Maintain capability for six on-orbit crew members.	1.1.1.1 Green	1.1.1.1 Green	1.1.1.1 Green	1.2.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: International Space Station	**Contributing Program:** International Space Station			

FY 2014 Performance Results

The International Space Station (ISS) enables humanity to have an ongoing presence in space, and allows crew members to conduct scientific and technology research that could not be done anywhere else. As NASA prepares 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-durations missions.

During FY 2014, NASA maintained a crew of six onboard the ISS, except during scheduled crew rotation periods. Crew members representing the United States, Russia, Japan, Canada, and Europe rotated every six months on the Russian Soyuz spacecraft. All of the required resupply flights, logistics, systems, and operational procedures continued to support a safe and effective ISS platform in space.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: In concert with International Partners, maintain a continuous six-crew capability on ISS by coordinating and managing resources, logistics, systems, and operational procedures.	9ISS6 Green	10ISS07 Green	ISS-11-1 Green	ISS-12-1 Green	ISS-13-1 Green	ISS-14-1 Green
Planned Future Performance						
For FY 2015: ISS-15-2: In concert with International Partners, maintain a continuous six-crew capability on ISS by coordinating and managing resources, logistics, systems, and operational procedures.						
For FY 2016: ISS-16-2: In concert with International Partners, maintain a continuous six-crew capability on ISS by coordinating and managing resources, logistics, systems, and operational procedures.						
Contributing Theme: International Space Station	**Contributing Program:** International Space Station					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Advance engineering, technology, and science research.	1.1.2.1 Green	1.1.2.1 Green	1.1.2.1 Green	1.2.3 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: International Space Station	**Contributing Program:** International Space Station			

FY 2014 Performance Results

During FY 2014, the International Space Station (ISS) supported a robust research and development program, allowing NASA to achieve all of its planned research objectives to advance engineering, technology, and scientific research.

On June 17-19, 2014, the American Astronautical Society, in cooperation with NASA and the Center for the Advancement of Science in Space, held its third annual ISS Research and Development Conference in Chicago, IL. More than 300 scientists and technologists attended the conference, which focused on ISS discoveries, applications, and opportunities in microgravity, space and Earth science, enabling technologies, and science, technology, engineering, and mathematics education. The conference also included a presentation of awards for the Most Compelling Scientific and Technology Results from the ISS in 2013.

During FY 2014, the ISS Program completed two national research campaigns at the NASA Space Radiation Laboratory (NSRL) at Brookhaven National Laboratory, the first in November 2013 and the second in May 2014. As astronauts spend an increasing amount of time in space, they are exposed to more ionizing radiation. Ionizing radiation is harmful to human beings, and prolonged exposure may result in tumors, cancer, genetic defects in offspring, or death. NSRL is working to understand and mitigate the possible risks to astronauts of exposure to space radiation. This work is critical to ensure the safety of astronauts on long-duration missions beyond low Earth orbit.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete two space radiation national research campaigns at the NASA Space Radiation Laboratory at Brookhaven National Laboratory.	No API this fiscal year	No API this fiscal year	ERD-11-4 Green	ERD-12-1 Green	ERD-13-1 Green	ERD-14-1 Green
Planned Future Performance						
For FY 2015: ERD-15-5: Begin ISS one-year mission joint U.S.-Russian research plan and initiate on-orbit research implementation.						
For FY 2016: ERD-16-5: Complete the U.S.-Russian joint human health and performance research project on the International Space Station one-year mission.						
Contributing Theme: Exploration Research and Development	**Contributing Program:** Human Research					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Accomplish a minimum of 90 percent of the on-orbit research and technology development objectives.	No API this fiscal year	No API this fiscal year	ISS-11-5 Green	ISS-12-6 Green	ISS-13-3 Green	ISS-14-3 Green
Planned Future Performance						
For FY 2015: ISS-15-3: Accomplish a minimum of 90 percent of the on-orbit research and technology development objectives.						
For FY 2016: ISS-16-3: Accomplish a minimum of 90 percent of the on-orbit research and technology development objectives.						
Contributing Theme: International Space Station	**Contributing Program:** International Space Station					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Ensure vital assets are ready, available, and appropriately sized to conduct NASA's Mission.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.2.4 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Space and Flight Support	**Contributing Program:** Human Space Flight Operations			

FY 2014 Performance Results

In FY 2014, the astronaut corps was sized appropriately and met all mission needs and health standards. Six U.S. astronauts executed 100 percent of their planned on-orbit mission objectives, enabling over 12,000 on-orbit crew hours during six expedition missions to the International Space Station (ISS).

In addition, NASA implemented refined crew qualification and selection criteria related to potential space-induced medical conditions, which is expected to increase the diversity of crew members eligible for longer mission assignments.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Appropriately size the astronaut corps to provide timely assignments based upon mission needs.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	SFS-14-7 Green
Planned Future Performance						
For FY 2015: SFS-15-1: Appropriately size the astronaut corps to provide timely assignments based upon mission needs.						
For FY 2016: SFS-16-1: Ensure the astronaut corps meets all mission-related training requirements and mission-related health standards.						
Contributing Theme: Space and Flight Support	**Contributing Program:** Human Space Flight Operations					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise.	1.1.2.2 Green	1.1.2.2 Green	1.1.2.2 Green	1.2.5 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: International Space Station	**Contributing Program:** International Space Station			

FY 2014 Performance Results

During FY 2014, NASA completed all of its annual performance indicators, demonstrating its focus on conducting basic scientific research aboard the International Space Station (ISS). Following are some of the major accomplishments in biological and physical research completed in FY 2014:

- On September 21, 2014, the Space Exploration Technologies Corporation (SpaceX) launched SpaceX-4 to the ISS. The payload included the 20 mice needed for the Rodent Research Hardware and Operations Validation (Rodent Research-1) investigation, a prolonged biological study of the effects of microgravity on animals.
- During FY 2014, NASA completed four Critical Design Reviews (CDRs). The CDR is a significant review that demonstrates that a design is mature enough for production. The CDRs were completed on the following experiments:
    1. Advanced Combustion via Microgravity Experiments (ACME). ACME is intended to improve efficiency, reduce pollutants, and prevent fires, especially for spacecraft, of advanced combustion systems.
    2. Advanced Colloids Experiment-Heated (ACE-H). Colloidal mixtures, which are small particles suspended in a fluid, are found in everyday household products, fuels, and foods. ACE-H will examine how heat affects the composition of colloidal mixtures. Colloidal mixtures may become the building blocks of future new materials.
    3. Observation and Analysis of Smectic Islands in Space (OASIS). OASIS will use a microgravity environment to advance the understanding of the physics of complex fluids.
    4. Packed Bed Reactor Experiment (PBRE). The packed bed reactor is a critical component of the leading water reclamation and air revitalization technologies used in life-support systems. PBRE will examine how a reduced gravity environment affects the performance and reliability of the reactors.
- In March 2014, NASA completed the Preliminary Design Review (PDR) for the Cold Atom Laboratory (CAL). The PDR ensures that the designs and systems selected are appropriate to the program's needs, that the risks have been assessed, and that the estimated cost and schedule baselines are acceptable. CAL 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.
- The Center for the Advancement of Science in Space (CASIS) released three Requests for Proposals, including remote sensing, materials science, and enabling technologies. The solicitations are intended to expand the use of the ISS by public and private organizations other than NASA.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete all pre-flight activities and be ready to support the launch of the first flight with animals.	9AC3 Green	10AC03 Green	ERD-11-1 Green	ISS-12-7 Green	ISS-13-6 Green	ISS-14-5 Green
Planned Future Performance						
For FY 2015: ISS-15-4: Carry out the first NASA Research Announcement-selected rodent research in the Rodent Research-2 project.						
For FY 2016: ISS-16-4: Carry out the NASA Research Announcement-selected research in the Rodent Research-3 project.						
Contributing Theme: International Space Station	**Contributing Program:** International Space Station					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Conduct successful Critical Design Reviews (CDR) for four physical science payloads and a Preliminary Design Review (PDR) for the Cold Atom Laboratory in FY 2014.	9AC2 Green	10AC02 Green	ERD-11-3 Green	ISS-12-9 Green	ISS-13-8 Green	ISS-14-6 Green
Planned Future Performance						
For FY 2015: ISS-15-5: Launch three physical science research payloads to ISS; select investigators and conduct the Pre-Ship Review for the Cold Atom Laboratory.						
For FY 2016: ISS-16-5: Deliver to the International Space Station the Advanced Combustion via Microgravity Experiments module to conduct research focused on developing combustion technology.						
Contributing Theme: International Space Station	**Contributing Program:** International Space Station					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: CASIS will release two Requests for Proposals, complete proposal evaluation, and select research projects for ISS execution in FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ISS-14-7 Green
Planned Future Performance						
For FY 2015: ISS-15-6: Through the Center for the Advancement of Science in Space (CASIS) cooperative agreement, release two Requests for Proposal, complete proposal evaluation, and select research projects for International Space Station execution in FY 2015.						
For FY 2016: ISS-16-6: Through the Center for the Advancement of Science in Space (CASIS) cooperative agreement, release two Requests for Proposal, complete proposal evaluation, and select research projects for International Space Station execution in FY 2016.						
Contributing Theme: International Space Station	**Contributing Program:** International Space Station					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Produce 450 peer-reviewed publications from projects in human research, space biology, and physical sciences.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ISS-14-8 Green
Planned Future Performance						
For FY 2015: ISS-15-7: Produce 500 peer-reviewed publications from projects in human research, space biology, and physical sciences.						
For FY 2016: ISS-16-7: Produce 500 peer-reviewed publications from projects in human research, space biology, and physical sciences.						
Contributing Theme: International Space Station	**Contributing Program:** International Space Station					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: ISS-16-9: Complete the data collection for the International Space Station Identical Twins Study, designed to better understand human genetic expression changes during spaceflight.						
Contributing Theme: International Space Station	**Contributing Program:** International Space Station					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Provide cargo transportation to support on-orbit crew members and utilization.	1.1.1.3 Green	1.1.1.3 Green	1.1.1.3 Green	1.2.6 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: International Space Station	**Contributing Program:** International Space Station			

FY 2014 Performance Results

During FY 2014, NASA continued to provide cargo transportation to the International Space Station (ISS), fully 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 European Space Agency's (ESA's) Automated Transfer Vehicle (ATV), the Space Exploration Technologies Corporation's (SpaceX's) Dragon spacecraft, and the Orbital Sciences Corporation's Cygnus automated cargo spacecraft.

In FY 2014, U.S. commercial providers completed four cargo flights to the ISS:

- In January 2014, the Orbital Science Corporation's first Commercial Resupply Services (CRS) flight, Orbital CRS-1, berthed with the ISS, delivering 1,465 kilograms of supplies, including research resupply, crew provisions, vehicle hardware, and spare parts.
- In April 2014, SpaceX's third CRS flight, SpaceX CRS-3, berthed with the ISS. SpaceX-3 CRS-3 carried 2,253 kilograms of supplies, including research resupply, crew supplies, vehicle hardware, and spare parts.
- In July 2014, Orbital's CRS-2 flight berthed with the ISS, delivering 1,600 kilograms of supplies. This included research resupply, crew provisions, food, vehicle hardware, and spare parts.
- In September 2014, SpaceX's CRS-4 flight delivered 2,216 kilograms of supplies, including research resupply, crew provisions, food, vehicle hardware, and spare parts.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete at least three flights by U.S.-developed cargo delivery systems, delivering research and logistics hardware to ISS.	No API this fiscal year	No API this fiscal year	No API this fiscal year	ISS-12-3 Green	ISS-13-2 Green	ISS-14-2 Green
Planned Future Performance						
For FY 2015: ISS-15-8: Complete at least three flights by U.S.-developed cargo delivery systems, delivering research and logistics hardware to ISS.						
For FY 2016: ISS-16-8: Complete at least three flights, delivering research and logistics hardware to the ISS, by U.S.-developed cargo delivery systems.						
Contributing Theme: International Space Station	**Contributing Program:** International Space Station					

Strategic Objective 1.3

Facilitate and utilize U.S. commercial capabilities to deliver cargo and crew to space.

Lead Office
Human Exploration and Operations Mission Directorate (HEOMD)

Goal Leader
Phil McAlister, Division Director, Commercial Spaceflight Development Division

Contributing Programs
Commercial Crew

Budget for Strategic Objective 1.3

Budget Authority (in $ millions)	Actual FY 2014	Enacted FY 2015	Requested FY 2016	Notional FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$696	---	$1,244	$1,185	$732	$173	$1

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
NASA will have the ability to utilize U.S. commercial space transportation capabilities to provide safe, reliable, and cost effective access to and from low Earth orbit and the International Space Station (ISS) for crew and cargo.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- Strategies are demonstrating success in achieving this strategic objective.
- Recent past performance of commercial cargo demonstrates several significant achievements.
- NASA's primary challenges are adequate budget availability and phasing of budget to maximize competition as NASA moves forward into the new Design, Develop, Test and Evaluate (DDT&E) and certification.

FY 2014 achievements included the following:

- The Commercial Crew Certification Products Contracts were completed.
- The Commercial Crew Transportation Capability (CCtCAP) contracts were awarded.

- The final Commercial Orbital Transportation Services (COTS) demonstration flight to the ISS was completed in October 2013.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

NASA is on track to achieve the agency priority goal by September 2015: "the Commercial Crew Program will complete the first phase of certification efforts with Commercial Crew Transportation partners, and will make measurable progress toward the second certification phase with industry partners while maintaining competition."

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

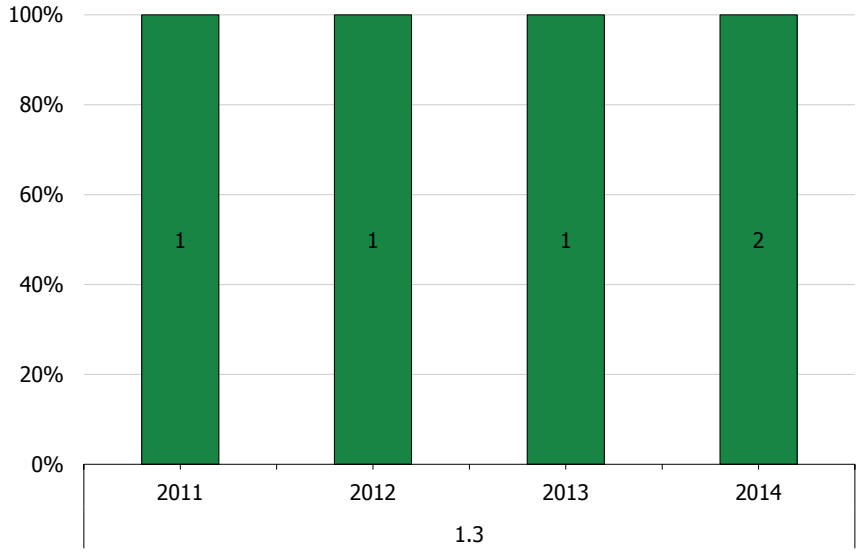
Next Steps in FY 2015

- NASA will continue monitoring partner milestone progress based on CCtCap contract content.

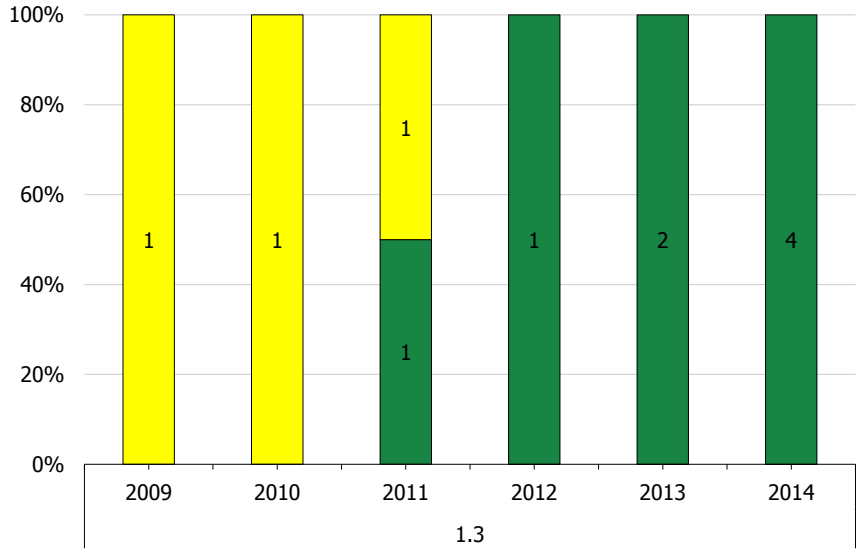
FY 2014 Performance Measures

Strategic Objective 1.3: Facilitate and utilize U.S. commercial capabilities to deliver cargo and crew to space.	
Performance Goal 1.3.1: Facilitate the development of and certify U.S. industry-based crew transportation systems while maintaining competition. (Agency Priority Goal)	Performance Goal 1.3.2: Invest financial and technical resources to stimulate efforts within the private sector to develop and demonstrate safe, reliable, and cost-effective space transportation capabilities.
Annual Performance Indicators	
• CS-14-1: Complete the Commercial Crew Certification Products Contracts. • CS-14-2: Award the second phase Commercial Crew Transportation System certification contracts.	• CS-14-4: Conduct Commercial Orbital Transportation Services (COTS) demonstration flight to ISS. • CS-14-5: Complete the evaluation of the Commercial Crew Transportation Capability (CCtCap) proposals and begin contract operations while maintaining competition.

Performance Goal Ratings for Strategic Objective 1.3, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 1.3, FY 2009 through FY 2014



Past fiscal years do not include annual performance indicators that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Facilitate the development of and certify U.S. industry-based crew transportation systems while maintaining competition. (Agency Priority Goal)	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.3.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Commercial Spaceflight	**Contributing Program:** Commercial Crew			

FY 2014 Performance Results

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.

In FY 2012, NASA initiated the first phase of crew transportation systems certification by awarding Certification Products Contracts (CPCs) to the Boeing Company, Sierra Nevada Corporation, and Space Exploration Technologies Corporation (SpaceX). Under the CPCs, the commercial partners worked with NASA to develop products that meet the Agency's flight safety and performance requirements and specifications. This included the certification across all aspects of the integrated system, including the spacecraft, launch vehicle, and ground and mission operations. In June 2014, NASA finalized and closed out the CPCs with its three commercial partners.

The second phase of certification reached a major milestone on September 16, 2014, when NASA awarded Commercial Crew Transportation Capability (CCtCap) contracts to the Boeing Company and SpaceX to transport U.S. crews to and from the ISS by 2017. The contracts include at least one crewed flight test per company, with at least one NASA astronaut on board to verify that the fully integrated rocket and spacecraft system can launch, maneuver in orbit, and dock to the ISS, as well as to validate that all systems perform as expected. Once each company's test program has been completed successfully and its system achieves NASA certification, each contractor will conduct at least two, and as many as six, crewed missions to the ISS.

More detailed information on this agency priority goal is included in Part 2 of this document.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the Commercial Crew Certification Products Contracts.	9CS9 Yellow	10CS07 Yellow	CS-11-2 Yellow	No API this fiscal year	CS-13-1 Green	CS-14-1 Green
Planned Future Performance						
For FY 2015: CS-15-1: Continue monitoring partner milestone progress based on Commercial Crew transportation Capability (CCtCap) contract content.						
For FY 2016: CS-16-1: Continue monitoring partner milestone progress based on Commercial Crew transportation Capability (CCtCap) contract content.						
Contributing Theme: Commercial Spaceflight	**Contributing Program:** Commercial Crew					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Award the second phase Commercial Crew Transportation System certification contracts.	No API this fiscal year	No API this fiscal year	CS-11-4 Green	CS-12-1 Green	CS-13-2 Green	CS-14-2 Green
Planned Future Performance						
For FY 2015: CS-15-2: Continue monitoring partner milestone progress based on agreement content.						
For FY 2016: No API this fiscal year						
Contributing Theme: Commercial Spaceflight	**Contributing Program:** Commercial Crew					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Invest financial and technical resources to stimulate efforts within the private sector to develop and demonstrate safe, reliable, and cost-effective space transportation capabilities.	1.2.1.1 Green	1.2.1.1 Green	1.2.1.1 Green	1.3.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Commercial Spaceflight	**Contributing Program:** Commercial Crew			

FY 2014 Performance Results

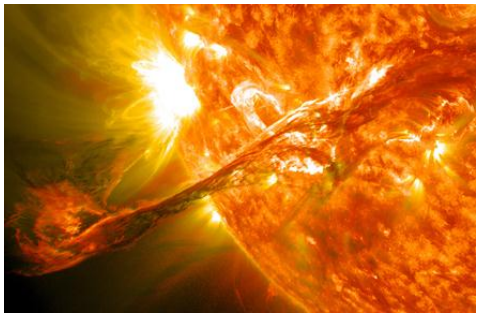
The NASA Commercial Crew Program is working with multiple U.S. companies that are designing and developing transportation capabilities to and from low Earth orbit and the International Space Station (ISS). By supporting the development by the private sector of human spaceflight capabilities, NASA is laying the foundation for future commercial transportation capabilities.

In March 2014, NASA solicited proposals from U.S. private enterprises to collaboratively develop new commercial space capabilities under its Collaborations for Commercial Space Capabilities (CCSC) initiative. The CCSC initiative will advance entrepreneurial efforts by giving private enterprises access to NASA's spaceflight resources. Using Space Act Agreements, NASA and its partners will agree to a series of mutually beneficial activities. The partnerships will have no exchange of funds, and each party will bear the cost of its participation. NASA's contributions through resulting Space Act Agreements could include technical expertise, assessments, lessons learned, technologies, and data. At the end of FY 2014, NASA was assessing the proposals submitted by industries for the CCSC effort.

CCSC is only one of several NASA partnership initiatives with the commercial space industry. For example, during FY 2014, the Commercial Crew Program also coordinated the Certification Products Contracts and Commercial Crew Transportation Capability contracts. This work is described in the FY 2014 Performance Results for Performance Goal 1.3.1. The Commercial Crew Program completed all work planned for FY 2014 for these contracts on schedule while maintaining competition.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Conduct Commercial Orbital Transportation Services (COTS) demonstration flight to ISS.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	CS-14-4 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Commercial Spaceflight	**Contributing Program:** Commercial Crew					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the evaluation of the Commercial Crew Transportation Capability (CCtCAP) proposals and begin contract operations while maintaining competition.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	CS-14-5 Green
Planned Future Performance						
For FY 2015: CS-15-3: Continue monitoring partner milestone progress based on agreement content.						
For FY 2016: CS-16-2: Continue monitoring partner milestone progress based on agreement content.						
Contributing Theme: Commercial Spaceflight	**Contributing Program:** Commercial Crew					



Strategic Objective 1.4

Understand the Sun and its interactions with Earth and the solar system, including space weather.

Lead Office
Heliophysics Division, Science Mission Directorate

Goal Leader
Dr. Jeffrey Newmark, Interim Director, Heliophysics Division

Contributing Programs
Living with a Star, Solar Terrestrial Probes, Heliophysics Research, and Heliophysics Explorer

Budget for Strategic Objective 1.4

Budget Authority (in $ millions)	Actual FY 2014	Enacted FY 2015	Requested FY 2016	Notional FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$641	---	$651	$685	$698	$708	$722

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
Further understanding of what causes the Sun to vary, how do the geospace, planetary space environments, and the heliosphere respond, and what are the impacts on humanity.

Update of Progress Toward Strategic Objective
NASA, in consultation with the Office of Management and Budget, has determined that performance toward this strategic objective is making noteworthy progress.

The NASA 2014 Strategic Review found that:

- Noteworthy progress is demonstrated by performance, cost, and schedule meeting planned progress, scientific achievements, and clear strategies being in place for continued success.
- Appropriate and sufficient strategies are in place to achieve the strategic objective.
- The Heliophysics flight program has demonstrated satisfactory cost and schedule performance.

- Risks and challenges have been identified and are being addressed appropriately; the division is taking advantage of a range of opportunities such as hosting a payload on a commercial communications satellite or Department of Defense spacecraft. The Heliophysics Division faces all the challenges articulated in the NASA 2014 Science Plan, Chapter 3.3.
- The October 2013 government shutdown contributed to cost growth and schedule delays for the Magnetospheric Multiscale (MMS) mission.

FY 2014 achievements include the following:

- On March 26, 2014, the Van Allen Probes mission achieved mission success.
- NASA's Interface Region Imaging Spectrograph (IRIS) spacecraft observed the low level of the Sun's atmosphere, a constantly moving area called the interface region, in better detail than has ever been achieved before.
- The MMS mission completed all observatory environmental testing.
- The NASA instruments (Heavy Ion Sensor and Heliospheric Imager) for Solar Orbiter successfully completed Critical Design Review.
- Solar Probe Plus (SPP) will be the first mission to fly into the Sun's atmosphere, or corona. SPP successfully completed Preliminary Design Review and was confirmed to enter into development.
- NASA's Voyager 1 spacecraft officially became the first human-made object to venture into interstellar space.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

NASA has instituted several process improvements designed to achieve greater insight into project performance including contractor cost performance. Specifically, NASA has enhanced project formulation by clarifying expected project maturities, instituting Formulation Agreements, implementing Joint Confidence Levels, establishing tools to provide schedule health checks, and requiring the use of Earned Value Management, a project management technique, on projects with a life-cycle cost estimate greater than $20 million, including in-house development work.

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

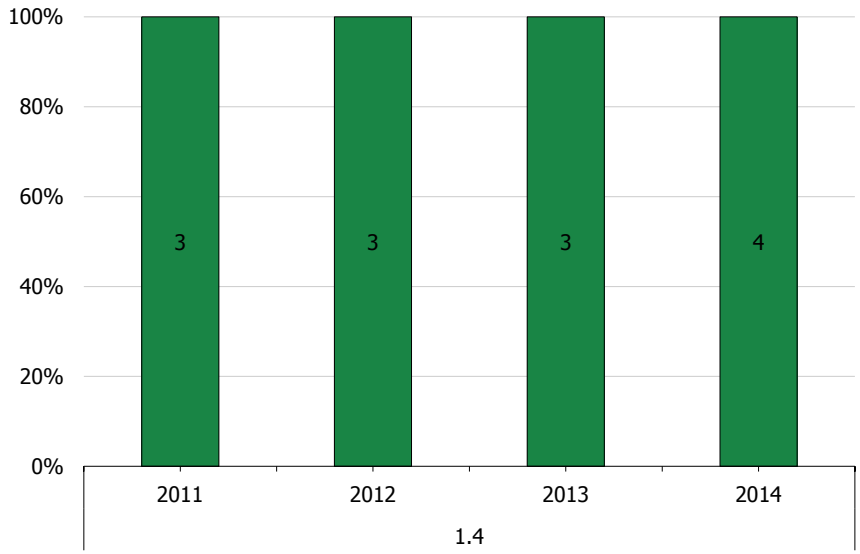
Next Steps in FY 2015

- Fund operating heliophysics missions in accordance with the 2013 Senior Review results.
- Prepare for launch of the MMS mission in FY 2015.
- Continue development of SPP and Solar Orbiter.
- Conduct Key Decision Point (KDP)-Cs for the Ionospheric Connection Explorer (ICON) and the Global-scale Observations of the Limb and Disk (GOLD) mission.
- Work with the National Oceanic and Atmospheric Administration (NOAA) and other agencies to ensure that agency responsibilities and activities related to space weather are clear, well-coordinated, and synergistic.

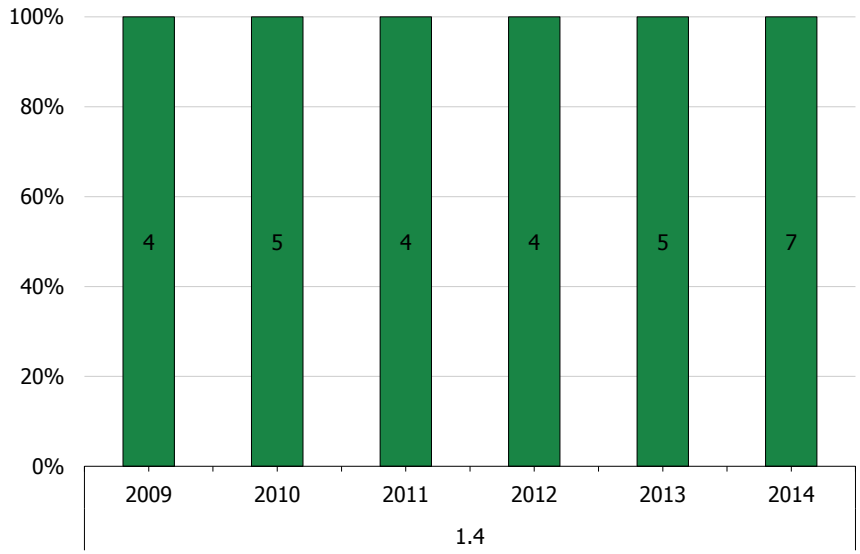
FY 2014 Performance Measures

Strategic Objective 1.4: Understand the Sun and its interactions with Earth and the solar system, including space weather.			
Performance Goal 1.4.1: Demonstrate progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.	Performance Goal 1.4.2: 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.	Performance Goal 1.4.3: 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.	Performance Goal 1.4.4: By December 2017, launch two missions in support of Strategic Objective 1.4.
Annual Performance Indicators			
• HE-14-1: Demonstrate planned progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system. • HE-14-2: Complete mission success criteria for the Van Allen Probes mission.	• HE-14-4: 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.	• HE-14-7: 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.	• HE-14-3: Complete Magnetospheric Multiscale (MMS) Observatory #4 Environmental Test. • HE-14-5: Complete Solar Orbiter Collaboration Heavy Ion Sensor (HIS) Instrument Critical Design Review (CDR). • HE-14-6: Complete Solar Probe Plus (SPP) Preliminary Design Review (PDR).

Performance Goal Ratings for Strategic Objective 1.4, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 1.4, FY 2009 through FY 2014



Past fiscal years do not include annual performance indicators that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.	2.2.1.1 Green	2.2.1.1 Green	2.2.1.1 Green	1.4.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Heliophysics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Heliophysics Subcommittee of the NASA Advisory Council Science Committee determined in September 2014 that NASA remained on track in its annual performance supporting achievement of this performance goal. Below are some of the achievements contributing to the fiscal year's progress.

Van Allen Probes Declared a Success

On March 26, 2014, NASA declared the Van Allen Probes mission, designed to explore and unlock the mysteries of Earth's radiation belts, an official success. This certification comes less than 19 months into the two-year primary mission of the twin spacecraft. This means the Van Allen Probes mission has met and surpassed its requirements for scientific instrument performance, mission operations, and scientific progress needed to achieve mission success.

Sounding Rocket Observes Coronal Heating

The Sun has four outer layers: the photosphere, chromosphere, transition region, and corona. The outermost layer, the corona, is much hotter than the others, with a temperature of over two million degrees Fahrenheit. Scientists find this phenomenon counterintuitive; they expect the layers to become cooler the farther they are from the surface of the sun. Data from a NASA sounding rocket have provided insight into the mechanisms that make the corona so hot.

The data were obtained by NASA's Extreme Ultraviolet Normal Incidence Spectrograph (EUNIS)-13 sounding rocket, which found the presence of pervasive faint high-temperature plasma (charged particles) in the corona. Scientists believe this plasma is due to small-scale heating events called nanoflares. These nanoflares occur within strands that form coronal loops, the building blocks of the corona. Models predicted that heating events occur on individual strands. Each of these heating events raises the strand plasma to temperatures of more than 18 million degrees. Previously, however, spacecraft have had difficulty observing these heating events. Using a very sensitive spectrograph, EUNIS-13 observed that the heating events behaved exactly as predicted by the nanoflare model, perhaps providing the "smoking gun" that confirms this theory.

Connections Between Earth's Lower Atmosphere and Near Space Environment

New data from the Aeronomy of Ice in the Mesosphere (AIM) spacecraft are the first to show the teleconnections in Earth's atmosphere that stretch from the North Pole to the South Pole and back again. Through these two-way connections, winter weather at Earth's surface in one hemisphere might be a harbinger of weather in the summer polar mesosphere in the other hemisphere.

When northern stratospheric winds slow down, they affect the southern mesosphere, which becomes warmer and drier. There also will be fewer noctilucent clouds, Earth's highest clouds. When the northern stratospheric winds speed up, the southern mesosphere becomes colder and wetter, and icy noctilucent clouds become more abundant. These complex interactions between atmospheric winds and waves produce what is called the stratospheric polar vortex, which leads to cold air outbreaks at the ground level. AIM data also show that the ripple effect takes about two weeks to affect the noctilucent clouds. This is likely how long it takes for changes to propagate through three layers of atmosphere (troposphere, stratosphere, and mesosphere) and from pole to pole. Surface temperatures in the United States from the Midwest to the Northeast during the bitter cold snaps in winter 2013-2014 and lagged noctilucent cloud frequencies correlate with wave activity in the stratosphere, the presumed forcing that led to both phenomena.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.	9HE1 Green	10HE01 Green	HE-11-1 Green	HE-12-1 Green	HE-13-1 Green	HE-14-1 Green
Planned Future Performance						
For FY 2015: HE-15-1: Demonstrate planned progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.						
For FY 2016: HE-16-1: Demonstrate planned progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.						
Contributing Theme: Heliophysics	**Contributing Program:** Multiple Programs					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete mission success criteria for the Van Allen Probes mission.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	HE-14-2 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Heliophysics	**Contributing Program:** Living with a Star					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	2.2.2.1 Green	2.2.2.1 Green	2.2.2.1 Green	1.4.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Heliophysics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Heliophysics Subcommittee of the NASA Advisory Council Science Committee determined in September 2014 that NASA remained on track in its annual performance supporting achievement of this performance goal.

Heliophysics System Observatory Tracks Energy Through Near-Earth Space

NASA scientists used data from the Heliophysics System Observatory to track the journey solar energetic particles take as they explode from the Sun and hurtle around Earth's magnetosphere.

Like Earth, the Sun also generates a magnetic field, created by flows of hot plasma that change shape and intensity much faster than Earth's. Scientists reconstructed the full three-dimensional magnetic field and total energy emitted from active regions in the solar photosphere (the visible surface of the Sun) using surface magnetic field and extreme-ultraviolet measurements from NASA's Solar Dynamics Observatory (SDO). As the magnetic field is propelled outward from the Sun, part of it is re-arranged and its energy impulsively accelerates solar energetic particles outward into the solar system.

Scientists thought such impulsive solar energetic particle acceleration events were isolated to large events. However, recent Solar TErrestrial RElations Observatory (STEREO), Solar and Heliospheric Observatory (SOHO), Hinode, and SDO observations showed that these events happen, at low levels, nearly all the time. These events may be brief and relatively localized, but they have a major effect. The injected solar energetic particles permeate the inner heliosphere (which falls between Earth and the Sun) and can be further accelerated to extremely high energies by interplanetary shocks ahead of coronal mass ejections, bubbles of gas and magnetic fields that explode from the outer atmosphere of the Sun. The emergent solar magnetic field also can affect geospace significantly as it passes by Earth. It compresses the magnetosphere, imparting magnetic energy into Earth's magnetized space environment that is then internally transformed to particle heating and acceleration. NASA's Two Wide-angle Imaging Neutral-atom Spectrometers (TWINS) mission has recently revealed that the properties of the solar driver are well imprinted on the heated ions in the inner magnetosphere.

IBEX and Voyager Help Paint an Evolving Picture of the Solar System's Boundaries

The Sun is surrounded by the heliosphere, a bubble of charged particles that extends far beyond the outer planets. The heliosphere is formed as the constant stream of particles from the Sun's solar wind flows outward in all directions until it slows down to balance the pressure from interstellar winds. In 2009, scientists reported that NASA's Interstellar Boundary Explorer (IBEX), which studies this distant boundary region from Earth's orbit, had detected a ribbon along the heliospheric boundary streaming energetic neutral atoms toward IBEX. Observations from the past five years have allowed scientists to build a new computer model of the orientation of the interstellar magnetic field draping around the heliosphere. The model shows a magnetic field that is nearly perpendicular to the motion of the solar system through the galaxy. This accounted for the uneven distribution of cosmic rays observed at Earth, where more cosmic rays arrive from the upwind direction. The model also suggests that the boundary that separates solar and interstellar plasmas, known as the heliopause, is very long, maybe two trillion miles in the downwind direction, and that the direction of the magnetic field beyond this boundary is quite different when compared to that observed by Voyager 1. NASA's Voyager 1 spacecraft entered this complex boundary region in 2004, where it collected data until it crossed into interstellar space in 2012. Though puzzling, these new results also provide important clues to the ways in which high-energy cosmic rays enter the solar system and reach Earth.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 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.	9HE6 Green	10HE06 Green	HE-11-4 Green	HE-12-4 Green	HE-13-4 Green	HE-14-4 Green
Planned Future Performance						
For FY 2015: HE-15-2: 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.						
For FY 2016: HE-16-2: 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.						
Contributing Theme: Heliophysics	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	2.2.3.1 Green	2.2.3.1 Green	2.2.3.1 Green	1.4.3 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Heliophysics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Heliophysics Subcommittee of the NASA Advisory Council Science Committee determined in September 2014 that NASA remained on track in its annual performance supporting achievement of this performance goal. Below are some of the achievements contributing to the fiscal year's progress.

Prolonged Solar Minimum Could Mean Increase in Galactic Cosmic Ray Intensities Near Earth

Sunspot activity increases and decreases throughout the Sun's 11-year cycles. The peak of the Sun's activity, known as solar maximum, is associated with more extreme solar activity, while solar minimum is a time of few sunspots. The last solar minimum, which began around 2008, was especially low, and protracted, and was followed by the current weak solar maximum. Using long term records of sunspot numbers, scientists have developed models to help them predict solar weather conditions in future cycles.

During the last solar minimum, spacecraft in NASA's Heliophysics System Observatory (HSO) observed the solar wind decline in speed, density, and temperature, and the heliospheric magnetic field weaken. Data also showed that as the heliospheric magnetic field weakened, galactic cosmic ray (high-energy particles from outside the solar system) intensities increased. In 2009, when the Sun was persistently quiet, galactic cosmic ray intensities were greater than ever before in the space age. Recently developed models show that a long declining trend may extend into future solar cycles. Two important implications are that the sunspot number and level of solar activity is expected to continue to decline, but galactic cosmic rays could increase significantly, posing a threat to human and robotic systems in space.

Magnetosphere Protects Earth from Space Weather Events

Observations have illustrated how the magnetic bubble surrounding Earth, the magnetosphere, helps deflect the impact of solar coronal mass ejections.

Coronal mass ejections, bubbles of gas and magnetic fields that explode from the outer atmosphere of the Sun, hurl magnetized particles into space. When coronal mass ejections from the Sun impact Earth they first encounter Earth's magnetic field at the outer boundary of the magnetosphere, known as the magnetopause. Matter and energy can cross the boundary into the magnetopause through the process of magnetic reconnection, where magnetic field lines disconnect and reconnect, releasing a burst of energy that can heat and accelerate particles.

On January 17, 2013, a coronal mass ejection impacted Earth, causing a modest magnetic storm and enhancing magnetospheric circulation. Using a network of ground-based Global Positioning System (GPS) receivers, researchers saw the cool dense plasma surrounding Earth in the region known as the plasmasphere be picked up by this enhanced circulation and swept outward towards the magnetopause. NASA's three Time History of Events and Macroscale Interactions during Substorms (THEMIS) spacecraft, which were about to cross the magnetopause, were engulfed by this cool, dense plasma. As each of the spacecraft crossed the magnetopause, they observed the characteristic signatures of magnetic reconnection; however, the reconnection rate was slowed by the presence of the cool dense plasma. GPS receivers on the ground observed the plasma, once it was on reconnected magnetic field lines, join the flow away from the Sun. These multipoint observations illustrate how the magnetosphere can self-regulate and confirm results of model simulations of the role of the plasmasphere in magnetospheric circulation. These models also are significantly improving scientists' ability to forecast space weather events.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 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.	9HE8 Green	10HE08 Green	HE-11-5 Green	HE-12-5 Green	HE-13-5 Green	HE-14-7 Green
Planned Future Performance						
For FY 2015: HE-15-3: 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.						
For FY 2016: HE-16-3: 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.						
Contributing Theme: Heliophysics	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
By December 2017, launch two missions in support of Strategic Objective 1.4.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.4.4 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Heliophysics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

NASA remains on track to achieve this performance goal by making progress toward launching two Heliophysics missions, Magnetospheric Multiscale (MMS) mission and the Ionospheric Connection Explorer (ICON).

In April 2014, engineers at Goddard Space Flight Center began testing all four MMS spacecraft to ensure that they will be able to withstand the extreme vibration and dynamic load they will experience during launch. MMS will study magnetic reconnection, the process where the Sun and Earth's magnetic fields connect and disconnect, explosively releasing energy. MMS currently will be ready for launch in early 2015.

ICON is a single spacecraft mission dedicated to understanding neutral-ion coupling in the Earth's upper atmosphere (thermosphere). It will resolve both long-standing and newly emerging questions about the mechanisms that control the daily development of plasma in Earth's space environment. The project completed both its System Requirements Review (SRR) and Preliminary Design Review (PDR) in FY 2014. NASA confirmed ICON to proceed into its implementation phase in October 2014.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete Magnetospheric Multiscale (MMS) Observatory #4 Environmental Test.	9HE2 Green	10HE02 Green	HE-11-2 Green	HE-12-2 Green	HE-13-3 Green	HE-14-3 Green
Planned Future Performance						
For FY 2015: HE-15-4: Launch the Magnetospheric Multiscale (MMS) mission.						
For FY 2016: No API this fiscal year						
Contributing Theme: Heliophysics	**Contributing Program:** Solar Terrestrial Probes					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete Solar Orbiter Collaboration Heavy Ion Sensor (HIS) Instrument Critical Design Review (CDR).	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	HE-13-6 Green	HE-14-5 Green
Planned Future Performance						
For FY 2015: HE-15-5: Initiate Solar Orbiter Collaboration launch integration activities at Kennedy Space Center.						
For FY 2016: No API this fiscal year						
Contributing Theme: Heliophysics	**Contributing Program:** Living with a Star					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete Solar Probe Plus (SPP) Preliminary Design Review (PDR).	No API this fiscal year	10HE04 Green	No API this fiscal year	No API this fiscal year	No API this fiscal year	HE-14-6 Green
Planned Future Performance						
For FY 2015: HE-15-6: Complete Solar Probe Plus (SPP) Critical Design Review (CDR).						
For FY 2016: HE-16-5: Complete Solar Probe Plus System Integration Review (SIR).						
Contributing Theme: Heliophysics	**Contributing Program:** Living with a Star					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: HE-15-7: Complete the Ionospheric Connection Explorer (ICON) Critical Design Review (CDR).						
For FY 2016: HE-16-6: Complete the Ionospheric Connection Explorer (ICON) System Integration Review (SIR).						
Contributing Theme: Heliophysics	**Contributing Program:** Heliophysics Explorer Program					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: HE-16-4: Release the next Heliophysics Explorer Announcement of Opportunity (AO).						
Contributing Theme: Heliophysics	**Contributing Program:** Heliophysics Explorer Program					

Strategic Objective 1.5

Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.

Lead Office
Planetary Science Division, Science Mission Directorate (SMD)

Goal Leader
Dr. James Green, Director, Planetary Science Division

Contributing Programs
Planetary Science Research Program, Lunar Quest Program, Discovery Program, New Frontiers Program and Mars Exploration Program, Outer Planets Program, Planetary Technology Program

Budget for Strategic Objective 1.5

Budget Authority (in $ millions)	Actual FY 2014	Enacted FY 2015	Requested FY 2016	Notional FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$1,346	---	$1,361	$1,420	$1,458	$1,502	$1,528

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
Further understanding of the content, origin, and evolution of the solar system, as well as the potential for life elsewhere.

Update of Progress Toward Strategic Objective
NASA, in consultation with the Office of Management and Budget, has determined that performance toward this strategic objective is making noteworthy progress.

The NASA 2014 Strategic Review found that:

- Noteworthy progress is demonstrated by performance, cost, and schedule exceeding planned progress, scientific achievements, and clear strategies being in place for continued success.
- Appropriate and sufficient strategies are in place to achieve the strategic objective.
- The Planetary Science flight program has demonstrated noteworthy cost and schedule performance (e.g., Lunar Atmosphere and Dust Environment Explorer (LADEE), Mars Atmosphere and Volatile EvolutioN (MAVEN), and Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-REx)).

- Risks and challenges have been identified and are being addressed appropriately. Many of the key challenges the Planetary Science Division faces in carrying out the 2014 Science Plan are common across all of the Science Mission Directorate (SMD) science divisions, and are well articulated in chapter 3.3 of the Science Plan.
- The division has identified and is taking advantage of a range of opportunities such as using a proven design for the next Mars rover to reduce costs and risks and partnering with other organizations, including the U.S. Geological Survey (USGS) Astrogeology Science Center in Flagstaff, AZ, on planetary cartography and mapping products.

FY 2014 achievements included the following:

- MAVEN launched on November 18, 2013, and arrived at Mars in September 2014.
- The Mars Science Laboratory (MSL) completed its mission success criteria.
- LADEE launched in September 2013 and completed its mission in April 2014.
- Completed Critical Design Reviews for the OSIRIS-REx and Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) missions.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

NASA has instituted several process improvements designed to achieve greater insight into project performance, including contractor cost performance. Specifically, NASA has enhanced project formulation by clarifying expected project maturities, instituting Formulation Agreements, implementing Joint Confidence Levels, establishing tools to provide schedule health checks, and requiring the use of Earned Value Management on projects with a lifecycle cost estimate greater than $20 million, including in-house development work.

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan. Additional information on strategies, challenges, implementation, and program-specific detail is available in the NASA 2014 Science Plan.

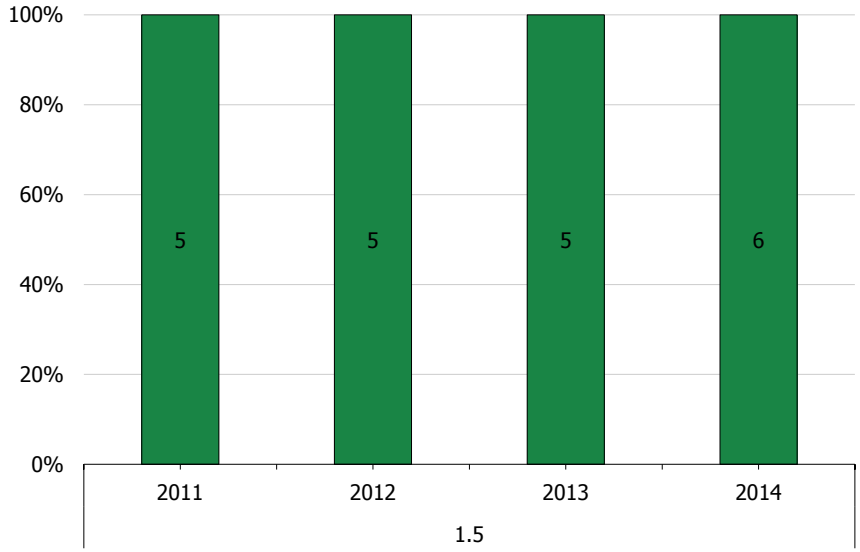
Next Steps in FY 2015

- Execute restructuring of the Planetary Science Research and Analysis program in the Research Opportunities in Space and Earth Sciences (ROSES)-14 solicitation, aligning research programs to the annual performance indicators.
- Strengthen the cross-divisional collaboration between Planetary Science and Astrophysics to conduct an exoplanets research program, focusing resources on this rapidly emerging field of study.
- Review the proposals for the 2014 Discovery Announcement of Opportunity and make selections. Discovery missions are principal investigator-led, small-class missions with focused scientific investigations.
- Continue implementation of the New Frontiers mission, OSIRIS-REx, and the Discovery mission, InSight.
- Continue formulation of NASA's contributions to fly on the European Space Agency's (ESA's) JUpiter ICy moons Explorer (JUICE) mission consisting of one U.S.-led science instrument and hardware for two European instruments: the radar, ultraviolet spectrometer, and the particle environment package.
- The Mars Rover 2020 mission will complete Phase A and begin Phase B (Formulation).

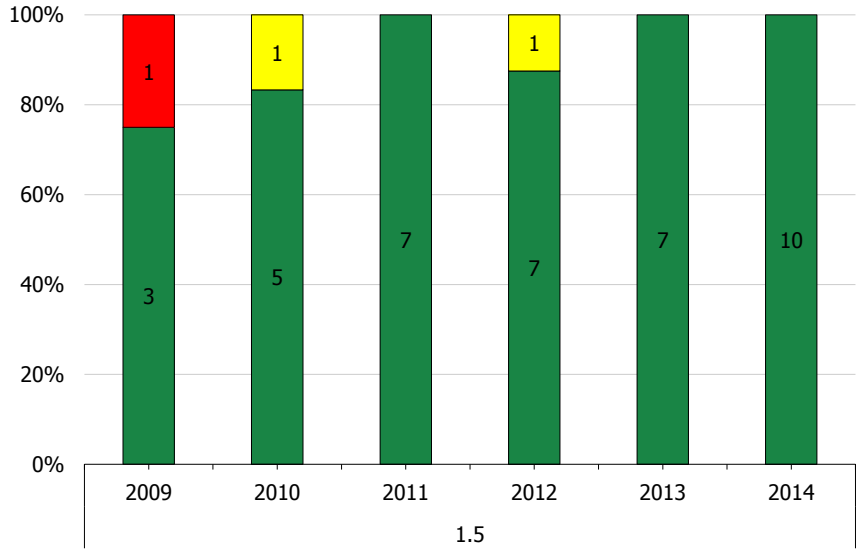
FY 2014 Performance Measures

Strategic Objective 1.5: Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.					
Performance Goal 1.5.1: Demonstrate progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact and evolve.	Performance Goal 1.5.2: Demonstrate progress in exploring and observing the objects in the solar system to understand how they formed and evolve.	Performance Goal 1.5.3: Demonstrate progress in exploring and finding locations where life could have existed or could exist today.	Performance Goal 1.5.4: Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.	Performance Goal 1.5.5: Demonstrate progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.	Performance Goal 1.5.6: By December 2017, launch at least two missions in support of Strategic Objective 1.5.
Annual Performance Indicators					
• PS-14-1: Demonstrate planned progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact and evolve.	• PS-14-4: Demonstrate planned progress in exploring and observing the objects in the solar system to understand how they formed and evolve.	• PS-14-5: Demonstrate planned progress in exploring and finding locations where life could have existed or could exist today. • PS-14-6: Complete mission success criteria for Mars Science Laboratory (MSL).	• PS-14-8: Demonstrate planned progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.	• PS-14-10: Conduct research into mitigation strategies utilizing observed characteristics and properties of those small bodies that pose a threat to terrestrial life. • PS-14-12: Demonstrate planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.	• PS-14-2: Complete the Origins Spectral Interpretation Resource Identification Security–Regolith Explorer (OSIRIS-REx) Critical Design Review (CDR). • PS-14-3: Complete the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission (Discovery 12) Critical Design Review (CDR). • PS-14-7: Launch the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission.

Performance Goal Ratings for Strategic Objective 1.5, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 1.5, FY 2009 through FY 2014



Past fiscal years do not include annual performance indicators that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact and evolve.	2.3.1.1 Green	2.3.1.1 Green	2.3.1.1 Green	1.5.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Planetary Science Subcommittee of the NASA Advisory Council Science Committee determined in September 2014 that NASA remained on track in its annual performance supporting achievement of this performance goal.

Mercury Has Shrunk Much More Than Previously Believed

Since its formation billions of years ago, Mercury has been shrinking as it cools. Unlike Earth, which has numerous tectonic plates, Mercury has a single rocky crust over a large, hot, fluid metallic core. As its crust cools and contracts, it has developed large numbers of geological features, such as lobate scarps (cliffs) and wrinkle ridges. A detailed global study of images taken by the MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) spacecraft of more than 5,900 such features shows that Mercury has contracted radially by as much as seven kilometers. This is much greater than previously estimates of 0.8 to 3 kilometers, which were based on incomplete data from the 1970s era Mariner 10 flyby. The new data are in much better agreement with thermal models, which are based on the history of heat production and loss and global contraction. They also have important implications for studying the planet's thermal, tectonic, and volcanic history, and the structure of its unusually large metallic core. Find out more at the MESSENGER Mission News site.

Evidence That Impacts Melted the Ancient Martian Crust

Scientists first observed flat-floored craters on Mars' surface in images taken by Mariner 4 in 1965. The craters' features were mysterious. Scientists hypothesized that the craters had a sedimentary origin. However, data from the Mars Odyssey orbiter show that these craters (approximately 3,300 identified) contain some of the rockiest materials on the planet, inconsistent with poorly consolidated sedimentary materials. In a recent study, the scientists determined that the majority of the rocky crater floors were filled approximately 3.5 billion years ago and are associated with the highest thermal inertia values and some of the most mafic materials—rock rich with iron and magnesium, such as basalt—identified on the planet. Thermal inertia describes the geological surface's resistance to temperature change as heat is added, providing information about the composition and density of the rock. The scientists concluded that the most likely scenario is volcanic infilling through fractures created by the impact event. The ancient Martian crust was likely thin. An impact could have generated conditions in the mantle that would have allowed for the eruption of lava directly into the crater. The surface would have melted enough to allow lava to flow to the surface and spread across the crater floor. This process was widespread and responsible for the eruption of significant volumes of material, inside and likely outside of craters.

LADEE Maps the Lunar Exosphere

The Lunar Atmosphere and Dust Environment Explorer, or LADEE, mapped the temporal and spatial distribution of the major components of the lunar exosphere. An exosphere is an atmosphere that is so thin and tenuous that its constituent molecules do not collide with each other. This type of thin atmosphere may be the most common type of atmosphere in the solar system. LADEE's Neutral Mass Spectrometer mapped helium, neon, and argon, determining that helium and neon are derived mainly from solar wind, while argon is largely internally derived. The abundance of argon in the exosphere increases during sunrise, as the Moon's surface cools and argon is released through desorption. LADEE's Ultraviolet Spectrometer mapped sodium and potassium, as well as identifying many other minor and trace constituents of the exosphere. The data from this mission are helping scientists unravel the sources and sinks of the various components of the lunar exosphere and will lead them to a better general understanding of how exospheres are created and evolve.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact and evolve.	No API this fiscal year	No API this fiscal year	PS-11-1 Green	PS-12-1 Green	PS-13-1 Green	PS-14-1 Green
Planned Future Performance						
For FY 2015: PS-15-1: Demonstrate planned progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.						
For FY 2016: PS-16-1: Demonstrate planned progress in advancing the understanding of how the chemical and physical processes in the solar system operate, interact, and evolve.						
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in exploring and observing the objects in the solar system to understand how they formed and evolve.	2.3.2.1 Green	2.3.2.1 Green	2.3.2.1 Green	1.5.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Planetary Science Subcommittee of the NASA Advisory Council Science Committee determined in September 2014 that NASA remained on track in its annual performance supporting achievement of this performance goal.

Asteroid Belt Reveals a Diverse Early Solar System

A new map of asteroids in the main belt, which is located between Mars and Jupiter, show that the asteroids are not grouped by composition, the result of an orderly solar system evolution. Instead, different types of asteroids were likely mixed together by planetary migration and subsequent dynamical processes.

Previous measurements of the asteroids in the main belt suggested a uniform, smooth change in composition from more highly reflective, stony asteroids closer to the Sun to dark, carbon-rich objects that were barely altered by solar heating in the belt's more distant regions. However, data from the Wide-field Infrared Survey Explorer (WISE) and the Sloan Digital Sky Survey have shown that while there is an overall gradient, the true picture is much more jumbled, with a wide range of different compositions scattered throughout the belt. Asteroids rich in minerals that require high temperatures to form have been found in the outer belt, while primitive objects are found close to its inner edge, revealing that the early migration of the giant planets turbulently scrambled the asteroids.

Model Explains Enceladus' Active South Pole Terrain

Saturn's moon Enceladus has very different hemispheres. Its south polar terrain is young and geologically active, with geysers, tectonic activity, and high heat flows, while its northern hemisphere is relatively ancient and stable. In the south polar terrain, jets of salty ice particles and gases spew from the moon's distinctive "tiger stripes," or long fractures. The tidal heating powering this activity—heat mainly generated by tidal forces arising from the orbital resonance between Enceladus and another moon, Dione—should be symmetric across Enceladus' equator: Heating near the south pole should be accompanied by heating near the north pole. Previous models of heat transport in the ice shell have been unable to explain the activity limited to the south pole.

New global, three-dimensional convection models show that the silicate core underlying the ice shell is not spherical. The asymmetry can cause convection, where warm ice and gases push upward until the surface becomes locally unstable and overturns, sending colder ice downward, where the cycle begins again. This is confined to the south pole. The activity can also occur episodically, explaining how this massive power output could occur, given the limited overall tidal heating available to Enceladus.

Dwarf Planet Redefines Solar System's Edge

NASA-supported scientists using ground-based observatories have discovered a dwarf planet that is believed to have the most distant orbit found beyond the known edge of the solar system. Until now, Sedna, which was discovered in 2003, was the only other object found beyond the Kuiper Belt edge.

At its closest orbit point to the Sun, the dwarf planet, designated 2012 VP113, is about 80 times the distance of Earth from the Sun, a measurement referred to as an astronomical unit (AU). Sedna's closest orbit to the Sun is about 76 AU. In comparison, the gas giants (e.g., Jupiter and Saturn) are found between 5 and 30 AU, and the Kuiper Belt, which is composed of hundreds of thousands of icy objects, including Pluto, ranges from 30 to 50 AU.

Scientists estimate 2012 VP113 to be 450 kilometers in diameter. It is likely one of hundreds of thousands of distant objects thought to inhabit the region in the solar system referred to as the inner Oort cloud. The similarity in the orbits found for 2012 VP113, Sedna, and a few other objects near the edge of the Kuiper Belt suggests the dwarf planet's orbit might be influenced by the potential presence of an as yet unseen planet up to 10 times the size of Earth.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in exploring and observing the objects in the solar system to understand how they formed and evolve.	9PS1 Green	10PS01 Green	PS-11-4 Green	PS-12-4 Green	PS-13-3 Green	PS-14-4 Green
Planned Future Performance						
For FY 2015: PS-15-2: Demonstrate planned progress in exploring and observing the objects in the solar system to understand how they formed and evolve.						
For FY 2016: PS-16-2: Demonstrate planned progress in exploring and observing the objects in the solar system to understand how they formed and evolve.						
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in exploring and finding locations where life could have existed or could exist today.	2.3.3.1 Green	2.3.3.1 Green	2.3.3.1 Green	1.5.3 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Planetary Science Subcommittee of the NASA Advisory Council Science Committee determined in September 2014 that NASA remained on track in its annual performance supporting achievement of this performance goal.

NASA Space Assets Detect Ocean Inside Saturn Moon

NASA's Cassini spacecraft and Deep Space Network have uncovered evidence that Saturn's moon Enceladus harbors a large underground ocean of liquid water, furthering scientific interest in the moon as a potential home to extraterrestrial microbes.

Researchers theorized the presence of an interior reservoir of water in 2005 when Cassini discovered water vapor and ice spewing from vents near the moon's south pole. The ocean was discovered using a concept called the Doppler Effect. As Cassini flies by Enceladus, its velocity is perturbed by variations in the moon's gravity field. The researchers detect the changes in velocity as changes in radio frequency, which are received by the Deep Space Network. The gravity measurements suggest a large, possibly regional, ocean about six miles deep, beneath an ice shell about 19 to 25 miles thick. The new data provide the first geophysical measurements of the internal structure of Enceladus, consistent with the existence of a hidden ocean inside the moon. Data show that the south polar jets are venting salty water and organic molecules, the basic chemical ingredients for life.

Model Shows What Kept Water Liquid on Mars

Liquid water is essential for known life. Evidence from Mars missions shows liquid water once flowed across its surface several billion years ago. For the water to have remained liquid, Mars had to have a thick atmosphere that included greenhouse gases. In a new study, astrobiologists use a model to show how these greenhouse gases may have kept the water flowing. They also provide insight into the potential habitability of ancient Mars.

Previous models showed that carbon dioxide was not enough to keep the surface temperature of early Mars above freezing. This model shows that carbon dioxide and molecular hydrogen together could have led to a greenhouse effect capable of raising temperatures high enough for liquid water to be stable 3.8 billion years ago. The presence of molecular hydrogen in Mars' ancient atmosphere is supported by evidence found in Mars meteorites.

Glycine May Indicate Past Life

A recent study shows how glycine, an amino acid that is one of the basic building blocks of life, might survive on planets and celestial bodies other than Earth. Although it is useful for understanding the delivery of compounds to the early solar system, the data are also relevant for planetary protection and understanding how different molecules survive in space.

In 2009, NASA researchers reported finding glycine in comet material returned to Earth by the Stardust spacecraft. Glycine's ubiquitous presence in space means it may have been delivered to early Earth and other planets by comets or interstellar dust. It was likely an ingredient in the first microbial cells on Earth. Additionally, glycine is part of many biomolecules and might survive in the environment after cells die, meaning it also may be important to the search for signs of past life on other planets.

For the recent study, scientists blasted glycine-containing ice and rock mixtures with radiation to see how long glycine survives in different environments before it is destroyed. These mixtures simulated Mars from the surface down to several meters and served both to shield the glycine from the direct effects of the radiation and to lower the temperature of the experiments. NASA's Mars Reconnaissance Orbiter (MRO) detected widespread deposits of glacial ice in the mid-latitudes of Mars, which may be prime locations to look for glycine. The study shows that glycine's survival time depends both on the temperature and relative percentage of ice: The faster glycine is shielded from sources of radiation, buried under the surface by soil and ice, the more likely it is to survive.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in exploring and finding locations where life could have existed or could exist today.	9PS8 Green	10PS09 Green	PS-11-8 Green	PS-12-7 Green	PS-13-6 Green	PS-14-5 Green
Planned Future Performance						
For FY 2015: PS-15-3: Demonstrate planned progress in exploring and finding locations where life could have existed or could exist today.						
For FY 2016: PS-16-3: Demonstrate planned progress in exploring and finding locations where life could have existed or could exist today.						
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete mission success criteria for Mars Science Laboratory (MSL).	9PS4 Red	10PS06 Yellow	PS-11-9 Green	PS-12-8 Green	No API this fiscal year	PS-14-6 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Planetary Science	**Contributing Program:** Mars Exploration					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: PS-16-10: Complete the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission success criteria.						
Contributing Theme: Planetary Science	**Contributing Program:** Mars Exploration					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.	2.3.4.1 Green	2.3.4.1 Green	2.3.4.1 Green	1.5.4 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Planetary Science Subcommittee of the NASA Advisory Council Science Committee determined in September 2014 that NASA remained on track in its annual performance supporting achievement of this performance goal.

Evidence of Crusty Impacts on Early Earth

Impact events during the first billion years of the solar system had long-lasting effects on the crust of early Earth, and evidence of these ancient impacts may still exist. The solar system was crowded with debris during the first billion years, and Earth was probably struck frequently. These collisions shaped the potential for life on worlds like Earth and Mars, by altering terrains, changing the composition of the crust, altering the atmosphere, and affecting the initial thermal conditions of the surface. A new study estimates how heat from the frequent impacts of the Late Heavy Bombardment would have affected Earth's surface.

Results indicate that melted rocks, pooling in the depressions of the impact craters, covered more than 10 percent of the surface to more than one kilometer thick, although only about 1 percent of the total crust down to 20 kilometers was melted at any given time. Also during this period, impact ejecta and vaporized rock were tossed into air and rained down around the planet. Although much of the evidence of ancient impacts on Earth is wiped away by weather and geology, this study used zircons, small crystals that act as clocks, measuring time since they were last heated above a particular temperature. Because impacts create heat, this study used zircons from rocks in the Jack Hills (formed about 3.9 billion years ago), as models of global zircons during this time and found that about 40 percent of these clocks had been at least partially reset. This concentration of impactors suggests that any organisms living in Earth's ocean during the Late Heavy Bombardment would be in significant peril.

Early Life Had Limited Raw Materials at Its Disposal

The origin of life occurred through natural processes that made use of mineral species available on the early Earth. Astrobiologists have shown that no more than 420 mineral species were present at or near the surface of Earth in its first 550 million years, the Hadean Eon. This represents only eight percent of the nearly 5,000 mineral species present today. Since life originated through natural processes that made use of these minerals, astrobiologists must take these limited inputs into account as they create origin of life models.

Minerals on ancient Earth were formed only by cooling molten rock (magma), and the alteration of this rock by hot water. Today, there are many more processes for forming minerals, many of them directly tied to the biosphere. This research helps narrow down which minerals may be required for life to originate on other planets, such as Mars.

Dining on Methane in the Cold, Dark Sea

Astrobiologists have revealed details about how symbiotic microorganisms ”eat” methane hydrate crystals on the ocean floor in cold, high-pressure ecosystems. Methane hydrates form in low-temperature and high-pressure environments around methane seeps on the ocean floor. Two microbes (one bacteria and one archaea) work together and use an enzyme with the rare trace metal tungsten to break down methane hydrates. This is the first time that tungsten has been found in enzymes from such a cold environment. Usually microbes use a more common metal—molybdenum.

As Earth oceans warm through climate change, massive amounts of methane will be released from methane hydrates, and this study helps scientists understand how this ecosystem could change and the role these microbes might play in Earth’s future climate. Additionally, this study provides insight into life’s potential in subsurface ocean environments on moons like Europa, Enceladus, and Titan.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.	9PS5 Green	10PS07 Green	PS-11-11 Green	PS-12-11 Green	PS-13-8 Green	PS-14-8 Green
Planned Future Performance						
For FY 2015: PS-15-4: Demonstrate planned progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.						
For FY 2016: PS-16-4: Demonstrate planned progress in improving understanding of the origin and evolution of life on Earth to guide the search for life elsewhere.						
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.	2.3.5.1 Green	2.3.5.1 Green	2.3.5.1 Green	1.5.5 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Planetary Science Subcommittee of the NASA Advisory Council Science Committee determined in September 2014 that NASA remained on track in its annual performance supporting achievement of this performance goal.

NEOWISE Finds Dark Near-Earth Objects

The recently reactivated Wide-field Infrared Survey Explorer (WISE) has been tasked with a new mission to discover and characterize near-Earth objects (NEOs). Renamed NEOWISE, the spacecraft scans the dawn and twilight sky in infrared light (3.4 and 4.6 micron wavelength bands), searching for very dark NEOs that are often difficult for ground-based visible telescopes to find. Their dark surfaces indicate a primitive composition that is less likely to have been altered by the Sun's heat and are more likely to contain water-rich minerals and ices buried beneath their surfaces. By finding, characterizing, and tracking these dark NEOs, NEOWISE is helping to identify objects that may make the best targets for future explorers.

Radar Imagery of Near-Earth Asteroid

On April 23, 2014, the NEOWISE spacecraft discovered a near-Earth asteroid designated "2014 HQ124." Follow-up observations showed that 2014 HQ124 would pass within about 1.3 million kilometers of Earth in June. 2014 HQ124 is classified a "potentially hazardous asteroid," which refers to asteroids 140 meters or larger that pass within 7.4 million kilometers of Earth's orbit around the Sun. There was no chance of an impact, but it was close enough to be observed by NASA's Deep Space Network antenna at Goldstone, California, and the Arecibo Observatory in Puerto Rico. These unique facilities obtained bistatic radar images of 2014 HQ124 on June 8, the day of its closest approach to Earth. Working together, with Goldstone emitting and Arecibo receiving, they produced some of the most detailed images ever of a near-Earth asteroid. Radar measurements indicate 2014 HQ124 is approximately 370 meters along its long axis and appears to be a contact binary, where two objects migrate together until they form a single body. Additionally, large boulders appear to be on the surface of the body. 2014 HQ124 rotates approximately once every 20 hours.

Spitzer Characterizes an Asteroid for the Asteroid Redirect Mission

Observations taken in February 2014 by NASA's Spitzer Space Telescope of a very small near-Earth asteroid designated 2011 MD showed the asteroid could make a good candidate for the Asteroid Redirect Mission full capture concept. Analysis of Spitzer's infrared data show 2011 MD is roughly six meters in size. The analysis also revealed the asteroid's density must be remarkably low—about the same as water. Since solid rock is about three times as dense as water, about two-thirds of the asteroid must be empty space, suggesting it resembles a pile of rocks. The research team collecting the observations theorizes 2011 MD could be a collection of small rocks, held loosely together by gravity, or it might be one solid rock with a surrounding halo of small particles. In both cases, the asteroid mass could be captured by the mission's capture mechanism, and redirected to the Moon.

Near-Earth Object Survey

During FY 2014, asteroid search teams funded by NASA's Near-Earth Object Observations Program found another 13 asteroids larger than one kilometer in diameter with orbits that come close to Earth's vicinity. Asteroid search teams also found 1,072 smaller asteroids less than one kilometer in diameter, but no additional near-Earth comets. This brings the total known population of near-Earth objects to 11,341 (as of September 1, 2014). The high-precision

orbit predictions computed by NASA's Jet Propulsion Laboratory show that none of these objects is likely to strike Earth in the next century. However, 1,495 small bodies (of which 155 are larger than one kilometer in diameter), with 77 found this year, are in orbits that could become a hazard in the more distant future and warrant continued monitoring.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Conduct research into mitigation strategies utilizing observed characteristics and properties of those small bodies that pose a threat to terrestrial life.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	PS-14-10 Green
Planned Future Performance						
For FY 2015: PS-15-5: Conduct research into mitigation strategies utilizing observed characteristics and properties of those small bodies that pose a threat to terrestrial life.						
For FY 2016: PS-16-5: 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.						
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	PS-14-12 Green
Planned Future Performance						
For FY 2015: PS-15-9: Demonstrate planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.						
For FY 2016: PS-16-9: Demonstrate planned progress in identifying and characterizing objects in the solar system that pose threats to Earth or offer resources for human exploration.						
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
By December 2017, launch at least two missions in support of Strategic Objective 1.5.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.5.6 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Planetary Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

NASA launched the first mission supporting this performance goal, the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft, in November 2013. MAVEN entered orbit around Mars on September 21, 2014, and began testing its instruments. The mission will explore Mars' upper atmosphere, ionosphere, and interactions with the Sun and solar wind. Scientists will use 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' atmosphere and climate, liquid water, and planetary habitability.

In April 2014, NASA completed the Critical Design Review (CDR) for the Origins Spectral Interpretation Resource Identification Security–Regolith Explorer (OSIRIS-REx), giving the mission the go ahead to begin final design and fabrication. OSIRIS-REx will return a sample from near-Earth asteroid Bennu. 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.

NASA also made progress on another mission supporting Strategic Objective 1.5, the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight), by completing the CDR in May 2014. InSight is a geophysical lander that will use a suite of instruments to delve deep beneath the surface of Mars. It will study the processes that shaped the rocky planets of the inner solar system, including Earth, more than four billion years ago.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the Origins Spectral Interpretation Resource Identification Security–Regolith Explorer (OSIRIS-REx) Critical Design Review (CDR).	No API this fiscal year	10PS04 Green	PS-11-3 Green	PS-12-2 Yellow	PS-13-5 Green	PS-14-2 Green
Planned Future Performance						
For FY 2015: PS-15-6: Complete the Origins Spectral Interpretation Resource Identification Security - Regolith Explorer (OSIRIS-REx) Systems Integration Review (SIR).						
For FY 2016: PS-16-6: Complete the Origins Spectral Interpretation Resource Identification Security - Regolith Explorer (OSIRIS-REx) Pre-Ship Review (PSR).						
Contributing Theme: Planetary Science	**Contributing Program:** New Frontiers					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission (Discovery 12) Critical Design Review (CDR).	No API this fiscal year	No API this fiscal year	No API this fiscal year	PS-12-3 Green	PS-13-2 Green	PS-14-3 Green
Planned Future Performance						
For FY 2015: PS-15-7: Complete the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) Systems Integration Review (SIR).						
For FY 2016: PS-16-7: Launch the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission.						
Contributing Theme: Planetary Science	**Contributing Program:** Discovery					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Launch the Mars Atmosphere and Volatile EvolutioN Mission (MAVEN) mission.	No API this fiscal year	10PS08 Green	PS-11-10 Green	PS-12-9 Green	PS-13-7 Green	PS-14-7 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Planetary Science	**Contributing Program:** Mars Exploration					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: PS-15-8: Complete the Mars 2020 Preliminary Design Review (PDR).						
For FY 2016: PS-16-8: Complete Mars 2020 Mission Confirmation Review.						
Contributing Theme: Planetary Science	**Contributing Program:** Mars Exploration					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: PS-16-11: Complete down-select for Discovery 13 mission.						
Contributing Theme: Planetary Science	**Contributing Program:** Discovery					

Strategic Objective 1.6

Discover how the universe works, explore how it began and evolved, and search for life on planets around other stars.

Lead Office
Astrophysics Division, Science Mission Directorate (SMD)

Goal Leader
Dr. Paul Hertz, Director, Astrophysics Division

Contributing Programs
Astrophysics Research Program, Cosmic Origins Program, Physics of the Cosmos Program, Exoplanet Exploration Program, Astrophysics Explorer Program, James Webb Space Telescope (Webb)

Budget for Strategic Objective 1.6

	Actual	Enacted	Requested	Notional			
Budget Authority (in $ millions)	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$1,337	---	$1,329	$1,296	$1,304	$1,310	$1,336

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
Further understanding of the universe and how it works, its history, as well as the continued search for life beyond the solar system.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- Appropriate and sufficient strategies are in place to achieve the strategic objective, including the agency priority goal.
- The Astrophysics flight program has demonstrated satisfactory cost and schedule performance.
- Risks and challenges have been identified and are being addressed appropriately. Many of the key challenges the Astrophysics Division faces in carrying out the 2014 Science Plan are common across all of the SMD science divisions, and are well articulated in Chapter 3.3 of the Science Plan.
- The development of Webb is complex and continues to require close oversight by NASA Headquarters.
- The division has identified and is taking advantage of a range of opportunities.
- A number of particularly noteworthy scientific discoveries were announced in FY 2013.

FY 2014 achievements include the following:

- Webb continued to make good progress towards meeting its planned launch date of October 2018.
- In February 2014, the Kepler team announced the confirmation of more than 700 new exoplanets, at once tripling the number of confirmed planets discovered by the mission and increasing the number of known exoplanets to nearly 1,700.
- The Stratospheric Observatory for Infrared Astronomy (SOFIA) achieved Full Operational Capability (FOC) in February 2014.
- The Neutron star Interior Composition ExploreR (NICER) was confirmed in February 2014.
- NASA delivered the Astro-H Soft X-ray Spectrometer (SXS) calorimeter spectrometer insert to the Japan Aerospace Exploration Agency (JAXA) in March 2014.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

NASA has instituted several process improvements designed to achieve greater insight into project performance, including contractor cost performance. Specifically, NASA has enhanced project formulation by clarifying expected project maturities, instituting Formulation Agreements, implementing Joint Confidence Levels, establishing tools to provide schedule health checks, and requiring the use of Earned Value Management on projects with a lifecycle cost estimate greater than $20 million, including in-house development work.

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan. Additional information on strategies, challenges, implementation, and program-specific detail is available in the NASA 2014 Science Plan, as well as the 2013 Astrophysics Roadmap.

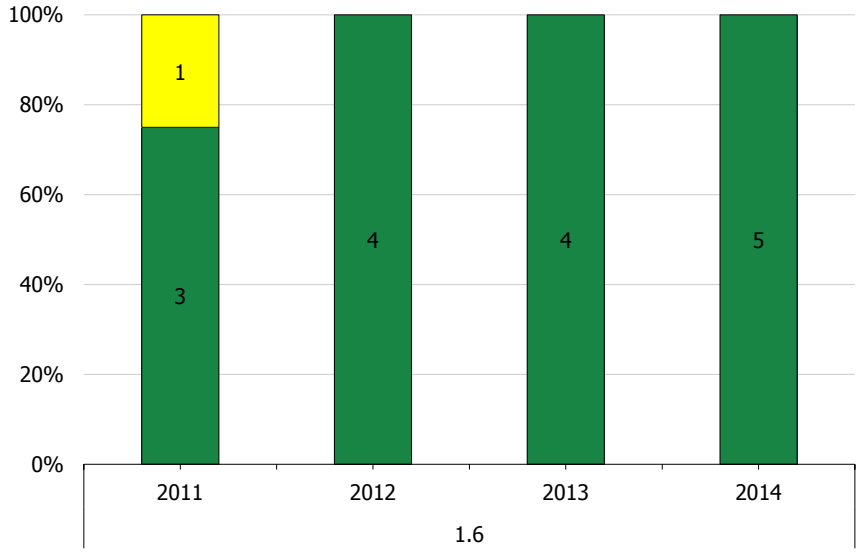
Next Steps in FY 2015

- Participate in the European Space Agency's mission concept study for their second large mission in the Cosmic Vision Programme, with the intent to establish a partnership on the mission.
- Plan for the Explorers Announcement of Opportunity. Astrophysics Explorers are principal investigator-led small- and medium-class missions with focused scientific investigations.
- Strengthen the cross-divisional collaboration between Astrophysics and Planetary Science to conduct an exoplanets research program, focusing resources on this rapidly emerging field of study.
- Complete the Critical Design Review (CDR) for the NICER mission.
- Deliver the Soft X-ray Spectrometer, NASA's contribution to the Astro-H mission, to JAXA.
- Complete Key Decision Point (KDP)-D for the International Space Station instrument Cosmic Ray Energetics and Mass, or ISS-CREAM.

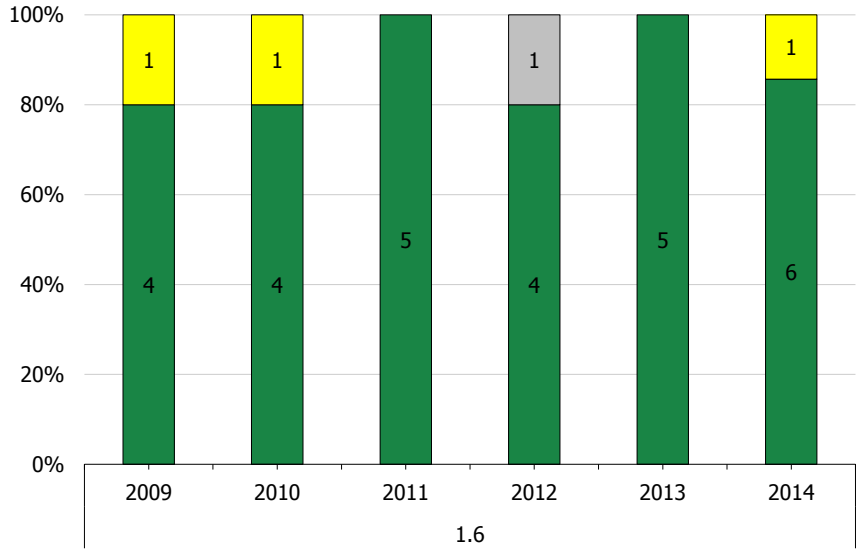
FY 2014 Performance Measures

Strategic Objective 1.6: Discover how the universe works, explore how it began and evolved, and search for life on planets around other stars.				
Performance Goal 1.6.1: Launch the James Webb Space Telescope. (Agency Priority Goal)	Performance Goal 1.6.2: Demonstrate progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.	Performance Goal 1.6.3: Demonstrate progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.	Performance Goal 1.6.4: Demonstrate progress in discovering and studying planets around other stars and exploring whether they could harbor life.	Performance Goal 1.6.5: By December 2018, launch at least one mission in support of Strategic Objective 1.6.
Annual Performance Indicators				
• JWST-14-1: Complete Webb Spacecraft Critical Design Review (CDR).	• AS-14-1: Demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity. • AS-14-2: Complete NuSTAR mission success criteria.	• AS-14-3: Demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe. • AS-14-5: Conduct Stratospheric Observatory for Infrared Astronomy (SOFIA) science flights to provide a minimum of 260 research hours.	• AS-14-6: Demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life.	• AS-14-7: Complete the Transiting Exoplanet Survey Satellite (TESS) System Requirements Review (SRR).

Performance Goal Ratings for Strategic Objective 1.6, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 1.6, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Launch the James Webb Space Telescope. (Agency Priority Goal)	2.4.2.2	2.4.2.2 Green	2.4.2.2 Green	1.6.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
For FY 2016: Launch the James Webb Space Telescope.				
Contributing Theme: James Webb Space Telescope	**Contributing Program:** James Webb Space Telescope			

FY 2014 Performance Results

The James Webb Space Telescope (Webb) is on track for launch by October 2018. NASA completed the Webb spacecraft Critical Design Review in January 2014, giving the program permission to begin final design and fabrication work on the spacecraft. The spacecraft will contain most of the steering and control machinery for the telescope.

The Webb Program also completed the static load testing of the primary mirror backplane support structure. This platform will hold the telescope's science instruments and 18 mirror segments that form the primary telescope mirror. The testing demonstrated that the backplane structure will be able to withstand the vibrations of launch and is the final test prior to its integration with the rest of the telescope. In addition, the program completed the second cryovacuum test of all the flight instruments with no significant issues arising during the testing.

The Webb Program has 11 of the originally baselined 13 months of funded schedule reserve to its October 2018 launch date. The Mid-InfraRed Instrument (MIRI) cryocooler system is the critical path, or pacing item, for the Webb schedule. In response to poor cost and schedule performance issues on the cryocooler system, NASA, the Jet Propulsion Laboratory (JPL), and Northrop-Grumman Aerospace Systems (NGAS) recently have made significant management changes and applied additional personnel from both NGAS and JPL, resulting in improved schedule performance thus far. The flight spare cryocooler cold head assembly and flight cryocooler electronics were delivered to JPL, and, more recently, in early FY 2015, the flight cold head assembly was delivered to Goddard Space Flight Center in time for Integrated Science Instrument Module cryotesting. The remaining cryocooler component (the compressor assembly) is scheduled for delivery in late spring 2015. Cryocooler designs have been verified to meet requirements, with only manufacturing and testing work remaining.

(The critical path of a mission is a dynamic quantity that changes with time depending on the challenges faced in designing, assembling, and testing the hardware and software.)

More detailed information on this agency priority goal is included in Part 2 of this document.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete Webb Spacecraft Critical Design Review (CDR).	9AS4 Green	10AS06 Green	JWST-11-1 Green	JWST-12-1 White	JWST-13-1 Green	JWST-14-1 Green
Planned Future Performance						
For FY 2015: JWST-15-1: Deliver James Webb Space Telescope flight backplane to Goddard Space Flight Center.						
For FY 2016: JWST-16-1: Deliver James Webb Space Telescope integrated optical telescope and science instrument module to Goddard Space Flight Center for testing.						
Contributing Theme: James Webb Space Telescope	**Contributing Program:** James Webb Space Telescope					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.	2.4.1.1 Green	2.4.1.1 Green	2.4.1.1 Green	1.6.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Astrophysics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Astrophysics Subcommittee of the NASA Advisory Council Science Committee determined in August 2014 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 2014.

Hubble Uncovers Largest Known Group of Star Clusters, Clues to Dark Matter

NASA's Hubble Space Telescope has uncovered the largest known population of globular star clusters, an estimated 160,000, swarming like bees inside the crowded core of the giant grouping of galaxies known as Abell 1689. The globular star cluster population in Abell 1689 is roughly twice as large as any other population found in previous globular cluster surveys. The Hubble study shows that most of the globular clusters in Abell 1689 formed near the center of the galaxy grouping, which contains a deep well of dark matter, the invisible gravitational scaffolding on which galaxies are built. The farther away from the galaxy core Hubble looked, the fewer globular clusters it detected. This observation corresponded with a comparable drop in the amount of dark matter, based on previous research.

Chandra and XMM-Newton Directly Measure Distant Black Hole's Spin

Astronomers have used NASA's Chandra X-ray Observatory and the European Space Agency's X-ray Multi-Mirror Mission (XMM-Newton) to show that a supermassive black hole six billion light-years from Earth is spinning extremely rapidly. This first direct measurement of the spin of such a distant black hole is an important advance for understanding how black holes grow over time. Astronomers determined the spin of the supermassive black hole that is pulling in surrounding gas, producing an extremely luminous quasar known as RX J1131-1231 (or RX J1131 for short). The astronomers used gravitational lensing, where the gravitational field of a giant elliptical galaxy along the line of sight to the quasar acts as a lens that magnifies the light from the quasar, to get detailed information about the black hole's X-ray spectrum. The X-rays are produced when a swirling accretion disk of gas and dust that surrounds the black hole creates a multimillion-degree cloud, or corona, near the black hole. X-rays from this corona reflect off the inner edge of the accretion disk.

The discovery that the black hole in RX J1131 is spinning at over half the speed of light suggests this black hole, observed at a distance of 6 billion light-years, corresponding to an age approximately 7.7 billion years after the Big Bang, has grown via mergers, rather than pulling material in from different directions.

RXTE Reveals the Cloudy Cores of Active Galaxies

Using data from NASA's Rossi X-ray Timing Explorer (RXTE), an international team has uncovered a dozen instances where X-ray signals from active galaxies dimmed as a result of a cloud of gas moving across the line of sight from Earth. The new study triples the number of cloud events previously identified in the 16-year archive.

At the heart of most big galaxies, including the Milky Way, lurks a supermassive black hole weighing millions to billions of times the Sun's mass. As gas falls toward a black hole, it gathers into an accretion disk and becomes compressed and heated, ultimately emitting X-rays. The centers of some galaxies produce unusually powerful emissions that exceed the Sun's energy output by billions of times. These are active galactic nuclei. This study is the first statistical survey of the environments around supermassive black holes and is the longest-running monitoring study of active galactic nuclei yet performed in X-rays.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.	9AS1 Green	10AS01 Green	AS-11-1 Green	AS-12-1 Green	AS-13-1 Green	AS-14-1 Green
Planned Future Performance						
For FY 2015: AS-15-1: Demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.						
For FY 2016: AS-16-1: Demonstrate planned progress in probing the origin and destiny of the universe, including the nature of black holes, dark energy, dark matter, and gravity.						
Contributing Theme: Astrophysics	**Contributing Program:** Multiple Programs					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete NuSTAR mission success criteria.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AS-14-2 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Astrophysics	**Contributing Program:** Astrophysics Explorer					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.	2.4.2.1 Green	2.4.2.1 Green	2.4.2.1 Green	1.6.3 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Astrophysics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Astrophysics Subcommittee of the NASA Advisory Council Science Committee determined in August 2014 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 2014.

Great Observatories Discover Ultra-Bright Young Galaxies

NASA's Hubble and Spitzer Space Telescopes joined forces to discover and characterize four unusually bright galaxies as they appeared more than 13 billion years ago, just 500 million years after the Big Bang. Although Hubble had previously identified galaxies at this early epoch, astronomers were surprised to find objects that are about 10 to 20 times more luminous than anything seen previously. The tiny galaxies are bursting with star formation activity, which accounts for their brilliance. The brightest one is forming stars approximately 50 times faster than the Milky Way does today. Although these fledgling galaxies are only one-twentieth the size of the Milky Way, they probably contain around a billion stars crammed together.

Hubble Helps Solve Mystery of Ultra-Compact, Burned-Out Galaxies

Astronomers using NASA's Hubble and Spitzer Space Telescopes and the European Space Agency's Herschel Space Observatory have pieced together the evolutionary sequence for compact elliptical galaxies that erupted and burned out early in the history of the universe. It provides a clear picture of the formation of the most massive galaxies in the universe, from their initial burst of star formation through their development of dense stellar cores to their ultimate reality as giant ellipticals. Using Hubble data, astronomers concluded that compact elliptical galaxies formed in intense starbursts inside the galaxies that preceded them by as long as two billion years. They also determined that these compact ellipticals voraciously consumed the gas available for star formation, to the point that they were unable to create new stars, and then merged with smaller galaxies to form giant ellipticals. The stars in the burned-out galaxies were packed 10-100 times more densely than in equally massive elliptical galaxies seen in the nearby universe today. Next, the team used the three space telescopes to study dust-enshrouded galaxies that were present early in the universe. They found that the violent starbursts in the dusty galaxies had the same characteristics that would have been predicted for progenitors to the compact elliptical galaxies.

NuSTAR Untangles Mystery of How Stars Explode

One of the biggest mysteries in astronomy, how stars blow up in supernova explosions, finally is being unraveled with the help of NASA's Nuclear Spectroscopic Telescope Array (NuSTAR). The high-energy X-ray observatory has created the first map of radioactive material in a supernova remnant. The results, from a remnant named Cassiopeia A (Cas A), reveal how shock waves likely rip apart massive dying stars. Cas A was created when a massive star blew up as a supernova, leaving a dense stellar corpse and its ejected remains. While small stars like the Sun die less violent deaths, stars at least eight

times as massive as the Sun blow up in supernova explosions. The high temperatures and particles created in the blast fuse light elements together to create heavier elements. In this case, the element is titanium-44, which has an unstable nucleus produced at the heart of the exploding star. Radioactive material like titanium glows clearly in X-rays. This allows NuSTAR to map what is happening at the core of the explosion.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.	9AS6 Green	10AS09 Green	AS-11-3 Green	AS-12-3 Green	AS-13-3 Green	AS-14-3 Green
Planned Future Performance						
For FY 2015: AS-15-2: Demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.						
For FY 2016: AS-16-2: Demonstrate planned progress in exploring the origin and evolution of the galaxies, stars, and planets that make up the universe.						
Contributing Theme: Astrophysics	**Contributing Program:** Multiple Programs					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Conduct Stratospheric Observatory for Infrared Astronomy (SOFIA) science flights to provide a minimum of 260 research hours.	9AS5 Yellow	10AS07 Yellow	AS-11-4 Green	AS-12-4 Green	AS-13-4 Green	AS-14-5 Yellow
Planned Future Performance						
For FY 2015: AS-15-3: Complete commissioning flights for the Stratospheric Observatory for Infrared Astronomy (SOFIA) Echelon-Cross-Echelle Spectrograph (EXES) science instrument.						
For FY 2016: AS-16-3: Complete commissioning flights for Stratospheric Observatory for Infrared Astronomy (SOFIA) second-generation instrument suite.						
Contributing Theme: Astrophysics	**Contributing Program:** Cosmic Origins					

Explanation of Rating

In February 2014, the Stratospheric Observatory for Infrared Astronomy (SOFIA), a 2.7-meter telescope mounted onboard a Boeing 747SP, reached full operational capability. The SOFIA platform experienced technical problems in November 2013, leading to the cancellation of six science flights. Although system reliability from that point onward was excellent, and NASA added four science flights in June 2014, these were not enough to overcome the loss of flights in November. SOFIA flew 258 research hours during FY 2014, missing the target for this annual performance indicator by only two research hours. As a result, NASA rated AS-14-5 yellow. This shortfall did not affect NASA's overall progress towards achieving Performance Goal 1.6.3.

In July 2014, NASA delivered SOFIA to the Lufthansa Technik facility in Hamburg, Germany, for performance of a scheduled Heavy Maintenance Visit. SOFIA received upgrades that brought the aircraft and telescope assembly maintenance up-to-date.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in discovering and studying planets around other stars and exploring whether they could harbor life.	2.4.3.1 Green	2.4.3.1 Green	2.4.3.1 Green	1.6.4 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Astrophysics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Astrophysics Subcommittee of the NASA Advisory Council Science Committee determined in August 2014 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 2014.

Kepler Provides Insights Into Wide Range of Enigmatic Planets

The Kepler spacecraft's haul of exoplanets continues to grow, revealing not just an abundance of planets, but also a surprising range of properties and architectures. Scientists studying the atmospheres and interiors of some of these worlds have found the signatures of water and the prevalence of clouds and hazes. Discoveries of small, rocky planets in a range of environments, including those that may allow for the presence of liquid water, increasingly indicate that Earthlike planets are likely ubiquitous.

In November 2013, during the second Kepler Science Conference, the Kepler team announced the discovery of over 800 new planet candidates, bringing the total number of new worlds discovered by Kepler to 3,538. This is an increase of nearly 30 percent since the last update, with the largest increase of 80 percent coming from small Earth-sized planets. Among these discoveries, scientists identified a number of unusual and unexpected systems. Using data from the W. M. Keck observatory in Hawaii, scientists measured the mass of two of these worlds: Kepler-99b and Kepler-406b. They are somewhat larger than the Earth, but have densities similar to lead. Similar observations have revealed a new type of rocky planet called a "Mega-Earth": Kepler-10c has a radius roughly twice the mass of Earth, but with a mass nearly 20 times greater. At the opposite extreme is KOI-314c. It has a mass similar to that of Earth, but has a radius that is 60 percent larger, implying it has a gaseous atmosphere much thicker than Earth's.

Looking for Water on Rocky and Jupiter-Like Planets

Detailed studies using the Spitzer and Hubble Space Telescopes are revealing new insights into the ubiquity of water and the presence of clouds on a wide range of worlds. Using a forensic analysis of the remains of a rocky world that crashed into its white dwarf host star, scientists measured the detailed composition of the world, finding evidence that it was very water-rich. On the other hand, measurements of the water abundance of three "hot Jupiters" indicate a surprisingly low level of water, less than a tenth to one-thousandth of that predicted by theory. Maps of Kepler-7b made using Spitzer and Hubble reveal high but patchy clouds in this hot, exotic Jupiter-sized world. Hubble observations of two smaller planets, GJ346b and GJ1214b, indicate both to be completely enshrouded in thick clouds.

Searching for Earthlike Planets

Using both Kepler and NASA-funded ground-based surveys, astronomers continued to make progress toward the discovery of Earthlike planets. In July 2014, scientists announced the discovery of an Earthlike planet orbiting one of the stars in a tight binary star system at a distance similar to which Earth orbits the Sun. Because the host star is much dimmer than the Sun, the planet is much colder. This study provides the first evidence that rocky planets can form in orbits similar to Earth's, even in a binary star system where the stars are not very far apart. In April 2014, scientists announced the discovery of Kepler-186f, the first Earth-size planet orbiting a star in the "habitable zone," the range of distance from a star where liquid water might exist on the surface. The discovery of Kepler-186f confirms that Earth-size planets exist in the habitable zone of other stars. The parent star of Kepler-186f is a red dwarf, a class of stars that are much more numerous than stars like the Sun, making up 70 percent of the stars in the Milky Way galaxy.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life.	9AS7 Green	10AS10 Green	AS-11-5 Green	AS-12-5 Green	AS-13-5 Green	AS-14-6 Green
Planned Future Performance						
For FY 2015: AS-15-5: Demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life.						
For FY 2016: AS-16-5: Demonstrate planned progress in discovering and studying planets around other stars and exploring whether they could harbor life.						
Contributing Theme: Astrophysics	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
By December 2018, launch at least one mission in support of Strategic Objective 1.6.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.6.5 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Astrophysics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

NASA has begun work on a new mission to support Strategic Objective 1.6. The Transiting Exoplanet Survey Satellite (TESS) will use an array of telescopes to perform the first-ever spaceborne all-sky 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 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. In February 2014, NASA completed the TESS System Requirements Review, which examined the mission's functional and performance requirements and determined that the requirements and the selected concept will satisfy the mission's needs. NASA is on track to launch TESS in late 2017.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the Transiting Exoplanet Survey Satellite (TESS) System Requirements Review (SRR).	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AS-14-7 Green
Planned Future Performance						
For FY 2015: AS-15-4: Complete the Transiting Exoplanet Survey Satellite (TESS) Mission Confirmation Review.						
For FY 2016: AS-16-4: Complete the Transiting Exoplanet Survey Satellite (TESS) instrument integration and test (I&T).						
Contributing Theme: Astrophysics	**Contributing Program:** Exoplanet Exploration					

Strategic Objective 1.7

Transform NASA missions and advance the Nation's capabilities by maturing crosscutting and innovative space technologies.

Lead Office
Space Technology Mission Directorate (STMD)

Goal Leader
Dorothy Rasco, Deputy Associate Administrator for Management, STMD

Contributing Programs
FY 2014: Crosscutting Space Technology Development (CSTD), Exploration Technology Development (ETD), Small Business Innovation Research / Small Business Technology Transfer (SBIR/STTR)
FY 2015 and 2016: Space Technology Research and Development (STRD), Small Business Innovation Research / Small Business Technology Transfer (SBIR/STTR)

Budget for Strategic Objective 1.7

	Actual	Enacted	Requested	Notional			
Budget Authority (in $ millions)	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$545	---	$692	$703	$714	$725	$736

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
Over the next 10 years—through STMD's crosscutting capability-based approach—the Agency's technology development accomplishments will have the following impacts: Reduced risk, reduced cost and increased capability for NASA human and robotic missions and the Nation; technology innovations and growth of the innovation community; and growth of the commercial space technology enterprise and the emergence of new markets. Efforts over the next 10 years include, but are not limited to, the following: high-data-rate communications for near-Earth and deep-space missions; green propellant; advanced in-space propulsion for both exploration and science missions; improved reliability and increased recycling in life support systems; advanced deep space navigation; and entry, descent, and landing technologies for planetary exploration.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- Clear progress towards the strategic objective has been demonstrated and sufficient strategies are in place.
- STMD is proceeding with ground tests and flight demonstrations of new crosscutting capabilities with the potential to transform future missions.

- STMD has responded to budget constraints as well as cost, schedule, and performance issues on individual technology efforts with both preventative and corrective actions to preserve eventual impact of new crosscutting technology capabilities.
- Some risks are acknowledged (such as sufficient budget and access to space), but mitigation strategies and opportunities are identified.

NASA achieved the following in FY 2014:

- During FY 2014, NASA successfully completed a major test of the Low-Density Supersonic Decelerator (LDSD).
- Completed major milestones for other Technology Demonstration Missions (TDM) projects, including Deep Space Atomic Clock (DSAC) and Composites for Exploration Upper Stage.
- Game Changing Development (GCD) completed pressure testing of a 5.5 meter Composite Cryogenic Tank, delivered operational legs for Robonaut2 to the International Space Station (ISS) on-board a SpaceX launch, and completed three Synchronized Position Hold Engage Reorient Experimental Satellites (SPHERES) slosh experiments on the ISS.
- Small Spacecraft Technology (SST) successfully flew PhoneSat 2.4 and 2.5.
- Flight Opportunities (FO) flew technology payloads using flight services from four providers: Zero-G, UP Aerospace, Masten, and Near Space.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

NASA has instituted several process improvements, including contractor cost performance, which are expected to improve oversight of STMD's program performance. Specifically, NASA has enhanced project formulation by clarifying expected project maturities, instituting Formulation Agreements, implementing Joint Confidence Levels, establishing tools to provide schedule health checks, and requiring the use of Earned Value Management on projects with a lifecycle cost estimate greater than $20 million, including in-house development work.

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

Next Steps in FY 2015

STMD will continue to explore early stage concepts, advance promising new technologies, and mature transformative solutions for flight demonstration. This approach will include continued emphasis on portfolio balance and lean, rapid technology development. STMD will also continue to emphasize partnerships within and outside the Agency. In FY 2015, STMD will pursue the following projects:

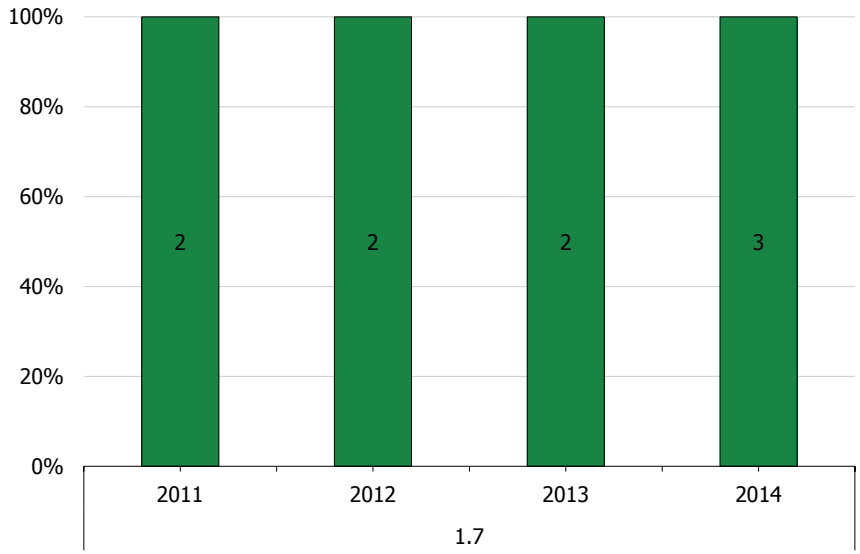
- The STMD LDSD project plans to conduct the second in a series of supersonic flight demonstration of a parachute and a supersonic inflatable aerodynamic decelerator. Together these technologies will allow for at least three times greater landed mass at Mars over Curiosity, and offer a pathway to landed masses as high as 15-metric tons for applications, such as human missions.
- STMD will increase the capabilities of small spacecraft by delivering for demonstration a variety of key small spacecraft components. These capabilities include, for example, demonstrating in-space laser communications using two CubeSats.
- To support living and working in deep space, Space Technology previously completed development of a new variable oxygen regulator and carbon dioxide removal system for next generation portable life support systems (PLSS). In FY 2015, STMD will support human-in-the-loop PLSS testing.
- STMD will conduct a Robonaut mobility demonstration using the legs delivered to ISS in FY 2014.
- STMD will conduct final payload integration and testing for the DSAC.

- For the Green Propellant Infusion Mission (GPIM), STMD will finalize integration of the propulsion and spacecraft systems and ensure the spacecraft and systems are prepared for the flight demonstration.

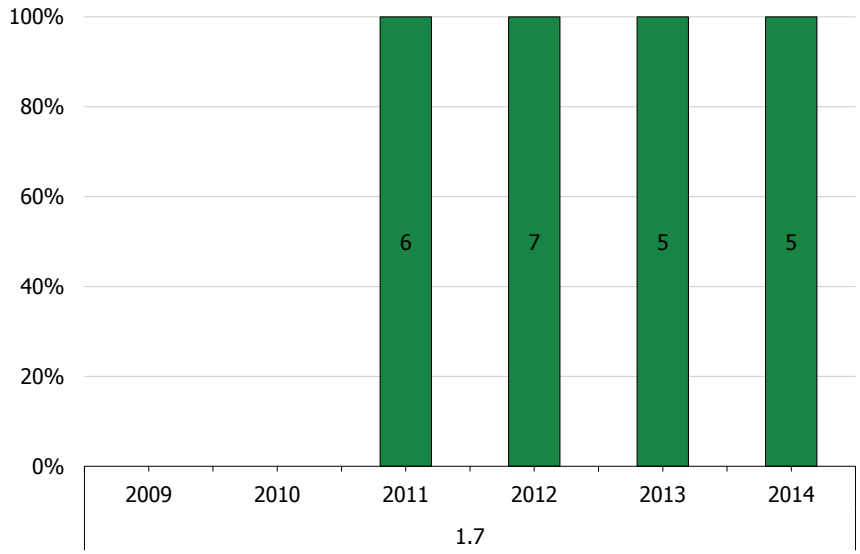
FY 2014 Performance Measures

Strategic Objective 1.7: Transform NASA missions and advance the Nation's capabilities by maturing crosscutting and innovative space technologies.		
Performance Goal 1.7.1: Explore and advance promising early stage solutions to space technology challenges through investment across the U.S. innovation community.	Performance Goal 1.7.2: Advance technologies that offer significant improvement to existing solutions or enable new space science and exploration capabilities.	Performance Goal 1.7.3: Mature new crosscutting space technology capabilities for demonstration.
Annual Performance Indicators		
• ST-14-1: Research, study, or develop concepts for 150 technologies, as documented in technology reports or plans.	• ST-14-2: Complete at least seven feasibility studies, ground demonstrations, or laboratory experiments proving the technical feasibility of new space technologies.	• ST-14-3: Complete four Key Decision Points for small spacecraft projects to demonstrate game changing or crosscutting technologies in space. • ST-14-4: Complete three Key Decision Points for Technology Demonstration Mission (TDM) technology development projects. • ST-14-5: Select and fly technology payloads from NASA, other government agencies, industry, and academia using flight services procured from at least four different commercial reusable suborbital or parabolic platform providers.

Performance Goal Ratings for Strategic Objective 1.7, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 1.7, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Explore and advance promising early stage solutions to space technology challenges through investment across the U.S. innovation community.	3.1.1.1 Green	3.1.1.1 Green	3.1.1.1 Green	1.7.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Space Technology	**Contributing Program:** Multiple Programs (FY 2014 and FY 2015: Crosscutting Space Technology Development)			

FY 2014 Performance Results

NASA is on track to meet this multiyear performance goal as the Agency continues to advance early stage innovation. The Space Technology Mission Directorate (STMD) develops 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 in FY 2014:

Accelerating Development Through Research Grants

NASA accelerates the development of low technology readiness level (TRL) space technologies, through research grants, to support future space science and exploration needs. Grants are selected through competitive solicitations for proposals from accredited U.S. universities. Through NASA Space Technology Research Fellowships, Early Career Faculty awards, and Early Stage Innovations awards, STMD engages a broad spectrum of academic researchers, from graduate researchers to senior faculty members. In FY 2014, NASA:

- Selected the 2014 class of NASA Space Technology Research Fellows;
- Selected seven Early Career Faculty Space Technology Research Grants; and
- Produced 178 NASA Space Technology Research Fellowships research training plans and 10 Early Stage Innovations technology reports.

More information is available on the Space Technology Research Grants Web site.

Investing in Innovative and Advanced Concepts

NASA invests in concepts with the potential to transform future aerospace missions, enable new capabilities, or significantly alter and improve current approaches. In FY 2014, NASA:

- Made excellent progress on innovative concept studies selected in prior fiscal years;
- Selected 17 new innovative concept studies comprising 12 Phase I projects and 5 Phase II projects; and
- Produced 12 Phase I and 2 Phase II final reports.

More information is available on the NASA Innovative Advanced Concepts Web site.

Encouraging Innovation Within NASA's Centers

NASA encourages creativity and innovation within the NASA Centers by supporting low-TRL initiatives that leverage Center talent and capability. In FY 2014, NASA:

- Selected and conducted Center Innovation Fund (CIF) projects at all 10 NASA Centers; and
- Produced 10 FY 2013 final reports during FY 2014, one for each of the NASA Centers, detailing the accomplishments of innovative studies that span NASA's 14 Technology Roadmaps.

More information is available on the CIF Web site.

Incentivizing Innovation Through Cash Prizes

NASA provides cash prize incentives to non-traditional sources for innovations of interest and value to the Agency and the Nation. As part of Centennial Challenges, NASA:

- Held the 2014 Sample Return Robot Challenge Competition in June 2014; and
- Selected for further development two new challenge ideas through the NASA@Work solicitation.

More information is available on the Centennial Challenges Web site.

Fostering Innovation at Small Businesses

NASA provides opportunities for small, high technology companies and research institutions to participate in government-sponsored research and development (R&D) efforts in key technology areas through its Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs. In FY 2014, NASA:

- Selected 383 SBIR Phase I projects, 108 SBIR Phase II projects, 32 STTR Phase I projects, and 23 STTR Phase II projects; and
- Executed 25 Phase II-Enhancement contract options to extend SBIR/STTR R&D in partnership with non-SBIR/STTR funding partners, and nine commercial readiness projects to create direct infusion potential for SBIR/STTR developed technology. The SBIR/STTR Programs continue to promote advancement to and beyond Phase II, working closely with other programs to identify and pursue potential collaborations. The SBIR Program post-Phase II advancement greatly exceeded expectations in FY 2014, especially given the inherent complexities in aligning willing external partners, appropriate technologies, and the right timing.

More information is available on the SBIR/STTR Web site.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Research, study, or develop concepts for 150 technologies, as documented in technology reports or plans.	No API this fiscal year	No API this fiscal year	ST-11-1 Green	ST-12-1 Green	ST-13-1 Green	ST-14-1 Green
Planned Future Performance						
For FY 2015: ST-15-1: Research, study, or develop concepts for technologies, as documented in 175 technology reports or plans.						
For FY 2016: ST-16-1: Research, study, or develop concepts for technologies, as documented in 200 technology reports or plans.						
Contributing Theme: Space Technology	**Contributing Program:** Space Technology Research and Development (FY 2014 and FY 2015: Crosscutting Space Technology Development)					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	ST-11-2 Green	ST-12-2 Green	No API this fiscal year	None
Planned Future Performance						
For FY 2015: ST-15-2: Conduct at least two Centennial Challenges competitions.						
For FY 2016: ST-16-2: Conduct at least three Centennial Challenges competitions.						
Contributing Theme: Space Technology	**Contributing Program:** Space Technology Research and Development (FY 2014 and FY 2015: Crosscutting Space Technology Development)					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: ST-16-3: Create three opportunities for advancement beyond Phase II SBIR/STTR.						
Contributing Theme: Space Technology	**Contributing Program:** SBIR and STTR					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Advance technologies that offer significant improvement to existing solutions or enable new space science and exploration capabilities.	3.2.1.1 Green	3.2.1.1 Green	3.2.1.1 Green	1.7.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Space Technology	**Contributing Program:** Space Technology Research and Development (FY 2014 and FY 2015: Crosscutting Space Technology Development)			

FY 2014 Performance Results

NASA is on track to meet this multiyear performance goal as the Space Technology Mission Directorate (STMD) continues to deliver improvements to existing capabilities, while also advancing promising new technology solutions.

Improving Existing Capabilities and Advancing Promising New Technology Solutions

During FY 2014, Game Changing Development (GCD) delivered the following technologies to NASA stakeholders:

- 3D printer hardware to the International Space Station (ISS). Testing a 3D printer aboard the ISS is the first step towards establishing an on-demand machine shop in space, a critical enabling component for deep-space crewed missions and in-space manufacturing.
- Lunar Advanced Volatile Analysis (LAVA) hardware to the Human Exploration and Operations Mission Directorate (HEOMD) for integration with the Regolith and Environment Science and Oxygen and Lunar Volatiles Extraction (RESOLVE) payload. LAVA is designed to identify and measure the relative abundance of volatile elements in the lunar regolith.
- Neutron Spectrometer hardware to HEOMD for integration with the RESOLVE payload.
- Robonaut 2 legs to the ISS. Robonaut 2 is a dexterous, anthropomorphic robot capable of handling simple, repetitive, or dangerous tasks aboard the ISS. The new climbing legs will improve the mobility of the Robonaut 2, freeing up the ISS crew for more critical work, including scientific research.

Also in FY 2014, STMD GCD continued advancement of many other promising technology solutions, including completion of feasibility studies, ground demonstrations, and laboratory experiments. These included the following accomplishments:

- Completed an environmental test program for the 5.5-meter diameter composite cryogenic propellant tank, which is being developed for future heavy lift vehicles and other in-space applications.
- Completed the assembly of a power conversion unit with two 6 electrical kilowatt Stirling engines for a nuclear power demonstration. Stirling power conversion potentially could be used in power generation systems on planetary surfaces.
- Completed a life test of the Rapid Cycle Amine hardware, which is designed to remove carbon dioxide and humidity from the ventilation loop of a spacesuit.
- Completed fabrication of a 3.7-meter diameter, second-generation inflatable hypersonic decelerator, which is designed to slow a vehicle during atmospheric reentry.
- Completed the development of woven Thermal Protection System (TPS) material billets. Woven TPS material can be manufactured rapidly and cost-effectively, and is able to withstand the heat of atmospheric entry.
- Completed three Synchronized Position Hold Engage Reorient Experimental Satellites (SPHERES)-Slosh experiments on ISS, which examine the physics of how liquids behave inside containers in space.
- Completed a series of hot-fire tests of an additively manufactured engine thrust chamber assembly. The hot-fire tests demonstrated a significant increase in performance over traditional combustion chamber designs and material systems.

More information is available on the GCD site.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete at least seven feasibility studies, ground demonstrations, or laboratory experiments proving the technical feasibility of new space technologies.	No API this fiscal year	No API this fiscal year	ST-11-7 Green	ST-12-7 Green	ST-13-2 Green	ST-14-2 Green
Planned Future Performance						
For FY 2015: ST-15-3: Complete at least eight feasibility studies, ground demonstrations, or laboratory experiments proving the technical feasibility of new space technologies.						
For FY 2016: ST-16-4: Complete at least seven feasibility studies, ground demonstrations, or laboratory experiments proving the technical feasibility of new space technologies.						
Contributing Theme: Space Technology	**Contributing Program:** Space Technology Research and Development (FY 2014 and FY 2015: Crosscutting Space Technology Development)					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Mature new crosscutting space technology capabilities for demonstration.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	1.7.3 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Space Technology	**Contributing Program:** Space Technology Research and Development (FY 2014 and FY 2015: Crosscutting Space Technology Development)			

FY 2014 Performance Results

NASA is on track to meet this multiyear performance goal as the Agency continues to mature new crosscutting space technology capabilities for demonstration.

Employing the Unique Features of Small Spacecraft

NASA develops and demonstrates new capabilities employing the unique features of small spacecraft for science, exploration, and space operations. As part of this effort, the Space Technology Mission Directorate (STMD):

- Flew PhoneSat 2.4 in November 2013 and PhoneSat 2.5 in March 2014. PhoneSat 2.4 and 2.5 are second-generation smart-phone-based satellites, and include numerous improvements over the previous generation, such as a two-way radio to enable command of the satellite from the ground, solar arrays to enable operation for up to a year, and a system for attitude control. These flights represent originally unplanned opportunities afforded by the success of PhoneSat 1.0.
- Made significant progress on other small spacecraft demonstration projects, including completion of major project lifecycle milestones for the Integrated Solar Array and Reflectarray Antenna (ISARA), the CubeSat Proximity Operations Demonstration (CPOD), and the Optical Communications and Sensor Demonstration (OCSD).

More information is available on the Small Spacecraft Technology Web site.

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 untold benefits for science and industry here on Earth—STMD seeks to mature laboratory-proven technologies to flight-ready status. In this area, STMD made significant progress on several technology demonstration projects in FY 2014:

- Completed a major demonstration of the Low-Density Supersonic Decelerator (LDSD) in June 2014. This was the first of three planned demonstrations to evaluate new technologies for future Mars missions. The LDSD demonstration met all flight objectives (i.e., the team launched the test vehicle to target altitude, conducted a powered flight, collected real-time telemetry, and recovered the balloon envelope). NASA deployed two new landing technologies during the test. The Supersonic Inflatable Aerodynamic Decelerator (SIAD), a large, doughnut-shaped deceleration technology, deployed first during the flight and was a success. The second deployment was that of an enormous parachute (i.e., the Supersonic Disk Sail Parachute). Imagery downlinked in real-time from the test vehicle indicated that the parachute did not deploy as expected, and the team is still analyzing data on the parachute so that lessons learned can be applied for future test flights. The next two flights include official tests of these landing technologies, involving identical saucer-shaped vehicles.
- Made significant progress on other Technology Demonstration Mission (TDM) projects, including completion of major project lifecycle milestones for the Deep Space Atomic Clock, Cryogenic Propellant Storage and Transfer, and Composites for Exploration Upper Stage.

More information is available on the Technology Demonstration Missions Web site.

Providing Flight Opportunities

NASA develops and provides flight opportunities for space technologies to be demonstrated and validated in relevant environments. During FY 2014, STMD flew technology payloads using flight services from four providers: Zero-G, UP Aerospace, Masten, and Near Space.

More information is available on the Flight Opportunities Web site.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete four Key Decision Points for small spacecraft projects to demonstrate game changing or crosscutting technologies in space.	No API this fiscal year	No API this fiscal year	No API this fiscal year	ST-12-9 Green	ST-13-3 Green	ST-14-3 Green
Planned Future Performance						
For FY 2015: ST-15-4: Complete four Key Decision Points for small spacecraft projects to demonstrate game changing or crosscutting technologies in space.						
For FY 2016: ST-16-5: Complete three Key Decision Points for small spacecraft projects to demonstrate game changing or crosscutting technologies in space.						
Contributing Theme: Space Technology	**Contributing Program:** Space Technology Research and Development (FY 2014 and FY 2015: Crosscutting Space Technology Development)					

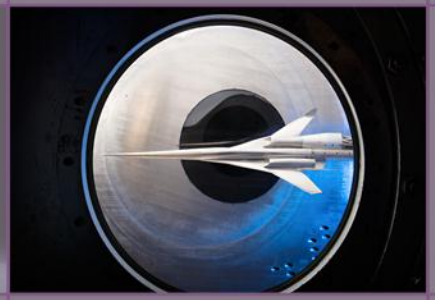
Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete three Key Decision Points for Technology Demonstration Mission (TDM) technology development projects.	No API this fiscal year	No API this fiscal year	ST-11-10 Green	ST-12-10 Green	ST-13-4 Green	ST-14-4 Green
Planned Future Performance						
For FY 2015: ST-15-5: Complete four Key Decision Points for Technology Demonstration Mission (TDM) technology development projects.						
For FY 2016: ST-16-6: Complete three Key Decision Points for Technology Demonstration Mission (TDM) technology development projects.						
Contributing Theme: Space Technology	**Contributing Program:** Space Technology Research and Development (FY 2014 and FY 2015: Crosscutting Space Technology Development)					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Select and fly technology payloads from NASA, other government agencies, industry, and academia using flight services procured from at least four different commercial reusable suborbital or parabolic platform providers.	No API this fiscal year	No API this fiscal year	ST-11-11 Green	ST-12-11 Green	ST-13-5 Green	ST-14-5 Green
Planned Future Performance						
For FY 2015: ST-15-6: 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.						
For FY 2016: ST-16-7: 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.						
Contributing Theme: Space Technology	**Contributing Program:** Space Technology Research and Development (FY 2014 and FY 2015: Crosscutting Space Technology Development)					

Strategic Goal 2

Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.

4
Strategic
Objectives



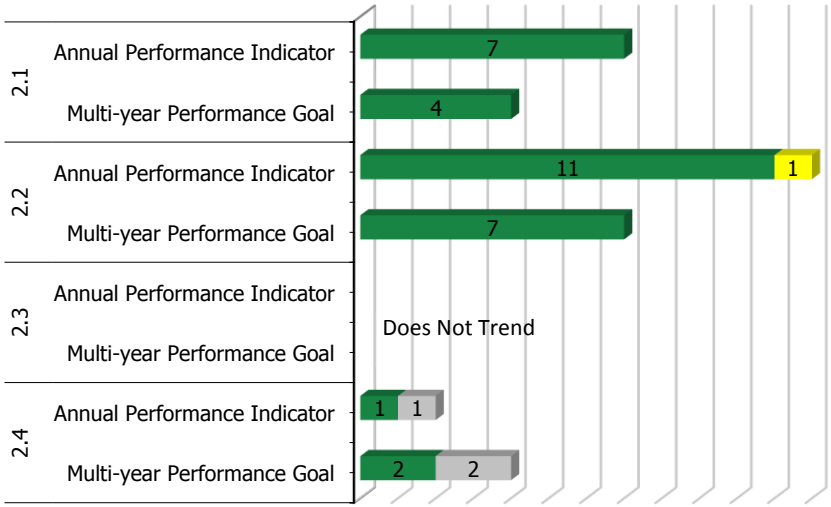
20
Performance
Goals

32
Annual
Performance
Indicators

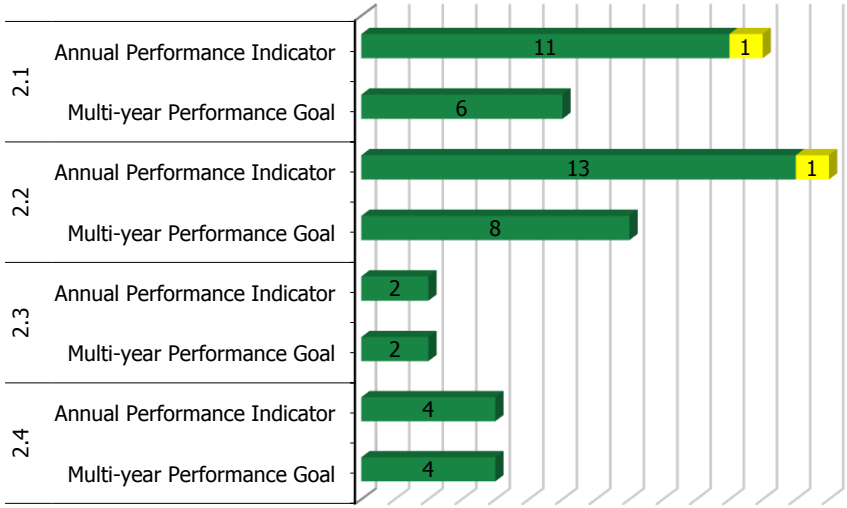
Strategic Goal 2: Advance understanding of Earth and develop technologies to improve the quality of life on our home planet.			
Strategic Objective 2.1: Enable a revolutionary transformation for safe and sustainable U.S. and global aviation by advancing aeronautics research.	Strategic Objective 2.2: Advance knowledge of Earth as a system to meet the challenges of environmental change, and to improve life on our planet.	Strategic Objective 2.3: Optimize Agency technology investments, foster open innovation, and facilitate technology infusion, ensuring the greatest national benefit.	Strategic Objective 2.4: Advance the Nation's STEM education and workforce pipeline by working collaboratively with other agencies to engage students, teachers, and faculty in NASA's missions and unique assets.
FY 2014 Performance Goals			
• 2.1.1: 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. • 2.1.2: Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft. • 2.1.3: Advance airframe and engine technologies to enable the development of future generations of ultra efficient aircraft that minimize environmental impact. • 2.1.4: Facilitate significant environmental and efficiency improvements through research on alternative jet fuel use and on hybrid gas-electric propulsion system concepts. • 2.1.5: Significantly increase the ability to anticipate and resolve potential safety issues and predict the health and robustness of aviation systems. • 2.1.6: 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.	• 2.2.1: 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. • 2.2.2: Demonstrate progress in improving the capability to predict weather and extreme weather events. • 2.2.3: Demonstrate progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle. • 2.2.4: 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. • 2.2.5: 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. • 2.2.6: 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. • 2.2.7: Further the use of Earth system science research to inform decisions and provide benefits to society. • 2.2.8: By December 2017, launch at least five missions in support of Strategic Objective 2.2.	• 2.3.1: Implement the five-year Strategic Plan to improve the ability to transfer NASA-developed technologies. • 2.3.2: Implement a process that enables the Agency to define and lead the Agency Grand Challenge.	• 2.4.1: Assure that students participating in NASA higher education projects are representative of the diversity of the Nation. • 2.4.2: Continue to support STEM educators through the delivery of NASA education content and engagement in educator professional development opportunities. • 2.4.4: 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. • 2.4.5: Continue to provide opportunities for learners to engage in STEM education engagement activities that capitalize on NASA-unique assets and content.

Summary of Performance for Strategic Goal 2

Comparison of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2013



Comparison of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2014

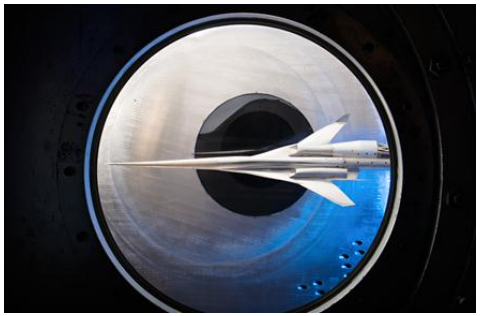


Summary of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2013

Strategic Goal 2					
Lead	**Objective**	**PGs**		**APIs**	
ARMD	2.1	4		7	
SMD	2.2	7		11	1
OCT	2.3	**Does Not Trend**			
Education	2.4	2	2	1	1
	Total	15		21	
	Summary	87% Green		90% Green	
				5% Yellow	
		13% White		5% White	

Summary of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2014

Strategic Goal 2				
Lead	**Objective**	**PGs**	**APIs**	
ARMD	2.1	6	11	1
SMD	2.2	8	13	1
OCT	2.3	2	2	
Education	2.4	4	4	
	Total	20	32	
	Summary	100% Green	94% Green	
			6% Yellow	



Strategic Objective 2.1

Enable a revolutionary transformation for safe and sustainable U.S. and global aviation by advancing aeronautics research.

Lead Office
Aeronautics Research Mission Directorate (ARMD)

Goal Leader
Mr. Robert A. Pearce, Director for Strategy, Architecture and Analysis, ARMD

Contributing Programs
FY 2014: Airspace Systems Program, Aviation Safety Program, Aeronautics Test Program, Fundamental Aeronautics Program, Integrated Systems Research Program
FY 2015 and FY 2016: Airspace Operations and Safety Program, Advanced Air Vehicles Program, Integrated Aviation Systems, Transformative Aeronautics Concepts Program

Budget for Strategic Objective 2.1

	Actual	Enacted	Requested	Notional			
Budget Authority (in $ millions)	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$566	---	$571	$580	$589	$598	$606

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
The success of the strategic objective and research can be determined by how well ARMD contributes to the six new research focus thrusts through the completion of the technical challenges in partnership with the aviation community.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- The new ARMD research strategy identifies six research thrusts with a list of expected outcomes associated with each thrust.
- This new strategy has significant stakeholder support.
- A reorganization of research programs to align with the new strategy is in progress, and the strategic implementation plan is in development.
- External reports generally have positive findings regarding the portfolio of programs and new strategic direction.
- There are no significant events or issues that would prevent ARMD from achieving the strategic objective.

FY 2014 achievements included the following:

- Conducted Alternative Fuel Effects on Contrails and Cruise Emissions (ACCESS) II flight testing.
- The Airspace Systems Program continued progress towards Air Traffic Management Technology Demonstration (ATD)-1, which will showcase an integrated set of technologies that provide an efficient arrival solution for managing an aircraft's descent from cruising altitude all the way down to the runway. One of the ATD-1 tools, the Terminal Sequencing and Spacing (TSS) tool, was officially transferred to the Federal Aviation Administration (FAA) in July 2014.
- Demonstrated an aerodynamic model enabling stall recovery training for commercial airline pilots.
- Completed Low Boom Flight Demonstrator Conceptual Design studies.
- Completed high-fidelity experimental and computer simulations to determine the potential benefit of the truss-braced wing technology concept.
- Modeled and designed a low alternating current-loss, fully superconducting electric generator for distributed propulsion aircraft configurations.
- Completed demonstration of a wireless sensor providing lightning protection.
- Conducted a human-in-the-loop simulation with piloted aircraft and unmanned aircraft mixed in a range of test conditions.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

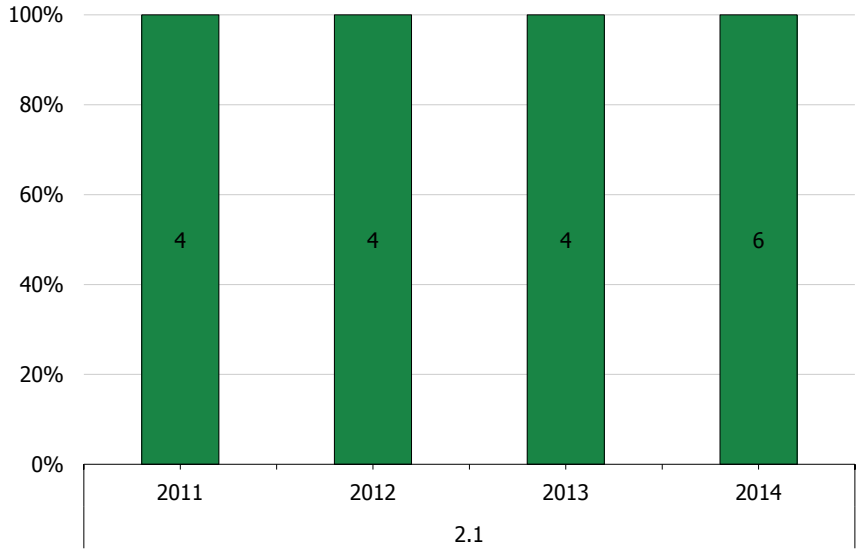
Next Steps in FY 2015

NASA Aeronautics research will align to the six long term strategic thrusts. Specific research in FY 2015 will focus on the following: reducing aircraft safety risks and increasing operational efficiency of air traffic management systems; developing and maturing portfolios of advanced airframe and engine technologies to achieve aggressive energy efficiency, noise, and emissions goals; continuing progress on reducing barriers to routine access of Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS); supporting national efforts to transition to alternative fuels and pioneer low carbon propulsion; accelerating the detection and prognosis of system-wide safety threats; taking first steps towards demonstrating the feasibility of low-boom supersonic vehicles; and establishing confidence in the safety of new automation software systems.

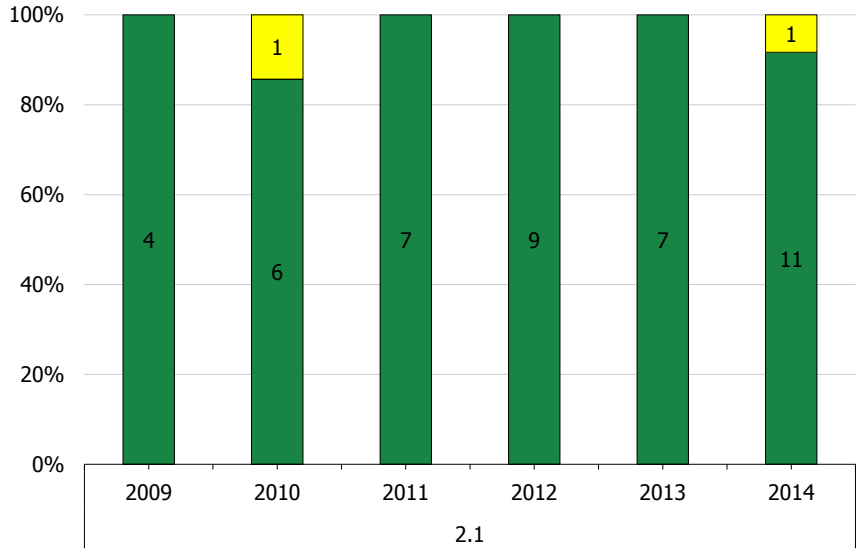
FY 2014 Performance Measures

Strategic Objective 2.1: Enable a revolutionary transformation for safe and sustainable U.S. and global aviation by advancing aeronautics research.					
Performance Goal 2.1.1: 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.	Performance Goal 2.1.2: Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.	Performance Goal 2.1.3: Advance airframe and engine technologies to enable the development of future generations of ultra efficient aircraft that minimize environmental impact.	Performance Goal 2.1.4: Facilitate significant environmental and efficiency improvements through research on alternative jet fuel use and on hybrid gas-electric propulsion system concepts.	Performance Goal 2.1.5: Significantly increase the ability to anticipate and resolve potential safety issues and to predict the health and robustness of aviation systems.	Performance Goal 2.1.6: 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.
Annual Performance Indicators					
• AR-14-3: Provide an integrated, high-fidelity simulator demonstration of an aerodynamic model that supports flight crew training requirements for assuring safe aircraft control. • AR-14-4: Develop a scheduling tool that reduces departure delays by enabling efficient aircraft departure and merging into open slots in the congested overhead traffic stream.	• AR-14-12: Complete Low Boom Flight Demonstrator (LBFD) conceptual design.	• AR-14-10: Execute data acquisition and control systems upgrades for the Glenn Research Center 10x10-Foot Supersonic Wind Tunnel. • AR-14-11: Execute data measurement techniques and flow quality improvements at the Langley Research Center National Transonic Facility. • AR-14-5: Use highly-detailed experimental and computer simulations to determine the potential of the truss-braced wing technology concept to enable reduced fuel use in transport aircraft. • AR-14-7: Demonstrate Ultra High Bypass (UHB) propulsion systems can be integrated with Hybrid Wing Body (HWB) concepts to meet fuel burn and noise goals. • AR-14-9: Conduct a successful Project Formulation Review and establish an advanced composites consortium to accelerate the development and certification process for advanced composite structures.	• AR-14-13: Model and design a fully superconducting electric generator for novel aircraft propulsion applications.	• AR-14-1: Conduct a ground-based demonstration of a wireless sensor that provides lightning protection and can detect and diagnose damage in composite structures.	• AR-14-2: Demonstrate use of an advanced software technique to verify the safety of a complex aircraft or ground automation software system. • AR-14-8: Conduct a human-in-the-loop (HiTL) simulation where unmanned aircraft are mixed with manned aircraft and subjected to a range of test conditions.

Performance Goal Ratings for Strategic Objective 2.1, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 2.1, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	4.1.2.1 Green	4.1.2.1 Green	4.1.2.1 Green	2.1.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Aeronautics	**Contributing Program:** Airspace Operations and Safety (FY 2014: Airspace Systems)			

FY 2014 Performance Results

During FY 2014, NASA continued progress towards Air Traffic Management Technology Demonstration (ATD)-1, which aims to improve arrival operations efficiency while increasing arrival throughput using integrated aircraft- and ground-based automation technologies. The Airspace Systems Program completed a full scale simulation of air traffic operations utilizing all technologies and procedures under development for ATD-1. This marks the end of the first phase of demonstration activities that involved development of prototype systems, integration of all of the technologies, and initial human-in-the-loop simulations in NASA laboratories. The next phase will involve development of the demonstration systems, follow-on simulations using Federal Aviation Administration (FAA) facilities and personnel, flight testing of avionics, and shadow testing of the integrated system. The last phase will finalize the demonstration plans and culminate in a field trial in a controlled, yet realistic operational environment. Initiated in FY 2011, ATD-1 is planned to complete in FY 2017 with a final technology transfer to the FAA of an integrated set of terminal arrival tools that will allow arrival aircraft to safely fly closer together on more fuel-efficient routes. This will increase capacity, reduce delay, and minimize fuel burn, noise, and greenhouse gas emissions. NASA delivered an ATD-1 tool, Terminal Sequencing and Spacing (TSS), to the FAA during an official ceremony held in July 2014. TSS technology provides information to controllers about the speeds they should assign to aircraft as they follow fuel-efficient, continuous-descent arrival procedures while passing through a region of airspace covering a distance from an airport of about 50 miles.

Simulation of large transport airplanes in upset conditions remains a topic of high interest to commercial aviation as part of the effort to reduce the risk of fatal loss-of-control accidents. During FY 2014, the Aviation Safety Program demonstrated an aerodynamic model that can enable stall recovery training for commercial airline pilots, surpassing the capabilities of current day simulators. The model was determined to be of sufficient fidelity for application to a flight training simulator environment, based on recommended simulator certification criteria for stalls being developed by relevant technical research and training organizations. The model data were validated by subscale aircraft flight tests, as well as other flight test and accident data.

The Airspace Systems Program's Spot and Runway Departure Advisor (SARDA) is designed to help tower controllers improve the efficiency of airport surface operations. During FY 2014, NASA completed three in a series of six human-in-the-loop (HITL) experiments using the Agency's FutureFlight Central facility to simulate SARDA-enabled operations at the US Airways ramp tower at Charlotte-Douglas International Airport. The next HITL simulation will incorporate a more advanced scheduler, providing new and enhanced advisories to ramp and tower controllers.

To accelerate transformation of the National Airspace System (NAS), the Airspace Systems Program is developing the Shadow Mode Assessments Using Realistic Technologies for the NAS, or SMART-NAS, capability, a live, virtual, and constructive environment where alternative future concepts, technologies, air-ground, human-machine architectures can be examined in an integrated fashion to assess NAS-level performance and benefits. As a first

step towards development, NASA made awards in FY 2014 to four teams tasked with developing an innovative NAS modeling architecture that will use a real-time, one-way feed of live aircraft traffic data and allow shadow-mode testing of advanced, gate-to-gate concepts in an integrated fashion to accelerate application of Next Generation Air Transportation System (NextGen) technologies.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Provide an integrated, high-fidelity simulator demonstration of an aerodynamic model that supports flight crew training requirements for assuring safe aircraft control.	9AT1 Green	10AT03 Green	AR-11-2 Green	AR-12-3 Green	No API this fiscal year	AR-14-3 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Aeronautics	**Contributing Program:** Aviation Safety					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Develop a scheduling tool that reduces departure delays by enabling efficient aircraft departure and merging into open slots in the congested overhead traffic stream.	No API this fiscal year	10AT06 Green	AR-11-4 Green	AR-12-6 Green	No API this fiscal year	AR-14-4 Green
Planned Future Performance						
For FY 2015: AR-15-1: Demonstrate the Concept of Operations for an integrated set of aircraft arrival technologies (ATD-1) that will provide for efficient performance during congested operations at busy airports.						
For FY 2016: AR-16-1: Develop an integrated Concept of Operations (ConOps) to reduce take-off time variability, thereby decreasing delays, aircraft wait time, and fuel usage, and conduct a simulation to demonstrate technologies that support the integrated ConOps.						
Contributing Theme: Aeronautics	**Contributing Program:** Airspace Operations and Safety (FY 2014: Airspace Systems)					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	2.1.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Aeronautics	**Contributing Program:** Advanced Air Vehicles (FY 2014: Fundamental Aeronautics)			

FY 2014 Performance Results

During FY 2014, NASA's Fundamental Aeronautics Program continued to conduct research and provide leadership in efforts to overcome the barriers to successful commercial supersonic aircraft. These include environmental barriers, such as sonic boom, airport noise, and high-altitude emissions, as well as efficiency barriers related to airframe, propulsion, and supersonic operations in the National Airspace System. Although work continues in all of these

areas, NASA's current focus is on the most significant barrier: sonic boom noise caused by the presence of shock waves when an aircraft flies faster than sound. The disturbance caused by sonic boom noise led to the implementation of Federal Aviation Administration (FAA) and international restrictions that essentially banned commercial supersonic flight over land, which in turn severely limited the potential market for civil supersonic aircraft. The program's sonic boom research addresses two of the most important aspects of the problem with the goal of creating key data that regulators can use to create a noise-based standard for certifying overland flight. The first aspect is understanding the sonic boom's acoustics and its impact on a community below, including how people react to hearing sonic booms when outside or indoors, and how quiet a boom needs to be before it is not considered an annoyance. The second aspect is developing and validating tools and techniques to enable the design of supersonic aircraft that produce acceptable sonic boom noise.

In the sonic boom response area, efforts focused on understanding response to sonic booms heard indoors. The Fundamental Aeronautics Program used the Interior Effects Room to study people's levels of annoyance in reaction to simulated sonic boom noise of varying degrees. A major accomplishment was the development and validation of software that can simulate sonic boom induced exterior pressure loading on buildings; transmission through building partitions (e.g., walls or windows); interior radiation of the transmitted pressures; and the resulting indoor acoustic environment. This software will enable researchers to generalize results from the Interior Effects Room to a wider variety of building sizes and types.

The low sonic boom design tool research continued to progress toward completion of a set of enhanced capabilities for full supersonic vehicle analysis. Building on previous airframe tool development, the team conducted a series of wind tunnel tests to validate tools used to predict the impact of engine inlet and nozzle flow on the overall sonic boom signature.

As the Aeronautics Research Mission Directorate continues its successful research into the two key aspects of the sonic boom barrier, it is considering what the next logical step toward development of a sonic boom standard might be. The conclusion reached is that a flight demonstration of low boom technology is the only way to achieve full validation and collect the required community response data in the most realistic environment—that of people in their own homes in any typical community. In FY 2014, the program completed a feasibility study for a Low Boom Flight Demonstration (LBFD). The purposes of this study were to develop a solid set of requirements for an LBFD, examine conceptual designs that could meet these requirements, and determine if such a demonstration would be affordable. Two airframe contractor teams and an internal NASA team participated. The teams were able to identify feasible approaches based on new low boom airframe designs that use a significant amount of existing components, such as engines, landing gear, and cockpit systems. The teams determined the requirements of the LBFD could be accomplished with a relatively small and, therefore, affordable demonstrator aircraft. The program initiated follow-on efforts aimed at refining the proposed concepts and identifying design risk areas. This effort is part of NASA's overall approach to making informed decisions about a future LBFD.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete Low Boom Flight Demonstrator (LBFD) conceptual design.	9AT9 Green	10AT09 Green	AR-11-8 Green	AR-12-10 Green	AR-13-5 Green	AR-14-12 Green
Planned Future Performance						
For FY 2015: AR-15-2: Develop full-vehicle analysis and optimization tools for multi-point low-boom supersonic aircraft design.						
For FY 2016: AR-16-2: Complete Low Boom Flight Demonstration (LBFD) Concept Refinement Studies.						
Contributing Theme: Aeronautics	**Contributing Program:** Advanced Air Vehicles (FY 2014: Fundamental Aeronautics)					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Advance airframe and engine technologies to enable the development of future generations of ultra efficient aircraft that minimize environmental impact.	4.1.3.1 Green	4.1.3.1 Green	4.1.3.1 Green	2.1.3 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Aeronautics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

During FY 2014, the Fundamental Aeronautics Program conducted detailed structural analyses and wind-tunnel testing for the truss-braced-wing airliner concept in NASA's Transonic Dynamics Tunnel. This concept was developed in partnership with Boeing as part of the Subsonic Ultra Green Aircraft Research (SUGAR) effort under NASA's Advanced Concept Studies for 2035 Subsonic Commercial Transport. The truss-braced wing is a promising technology for lighter-weight, lower-drag capability in transport aircraft. Post-test analysis verified the high fidelity finite element model of the structure, as well as the favorable weight estimates of the wing concept that support the fuel burn benefits of this aircraft configuration.

Additionally, the Fundamental Aeronautics Program conducted analysis and testing in NASA's 14x22-Foot Subsonic Wind Tunnel, which showed the aerodynamic benefits of the D8 concept with its "double-bubble" lifting fuselage and unique propulsion system placement. This concept was developed in partnership with the Massachusetts Institute of Technology, also as part of NASA's Advanced Concept Studies for 2035 Subsonic Commercial Transport. The design replaces the traditional cylindrical fuselage with two partial cylinders placed side-by-side. The engines sit atop the rear of the fuselage, rather than slung beneath the wing, to make use of a technique called boundary layer ingestion, where slower moving air from the wake of the fuselage enters the engines, resulting in less fuel consumption for the same amount of thrust.

The program also released a report called "CFD Vision 2030 Study: A Path to Revolutionary Computational Aerosciences," which discussed the need to substantially improve the current computational fluid dynamics (CFD) tools to meet the challenge of designing future air vehicles that will cut fuel consumption, reduce polluting emissions, and fly more quietly. The report also discussed how new algorithms must be written to take advantage of the ever-increasing speed and complexity of future supercomputers.

During FY 2014, the Integrated Systems Research Program's Environmentally Responsible Aviation project demonstrated, through analysis and testing, that ultra high bypass (UHB) propulsion systems can be integrated with hybrid wing body concepts to meet fuel burn and noise goals. Hybrid wing body configurations hold the promise of significantly reducing the environmental impact for commercial transport aircraft, offering advantages in noise reduction and fuel burn reduction not available to today's more standard tube-and-wing aircraft configurations. Additionally, the UHB engine offers the potential to dramatically reduce fuel burn and noise compared to the version of the aircraft engine commonly used by airliners today. The program continued its investigation of UHB technologies by conducting a wind tunnel test of a second-generation UHB engine model with optimized fan exit guide vanes. The program used the test to determine the effectiveness of those configurations to reduce noise and their impact on the performance of the engine. The wind tunnel results agreed with those predicted by state-of-the-art tools. Data from the test will contribute to a comprehensive performance database for modern UHB propulsor technologies that will be used by NASA and industry to update systems studies.

In addition, the program successfully conducted a formulation review that approved the implementation of the Advanced Composites project. The goal of this five-year project is to reduce the time required for certification of innovative composite materials and structures.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Execute data acquisition and control systems upgrades for the Glenn Research Center 10x10-Foot Supersonic Wind Tunnel.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AR-13-8 Green	AR-14-10 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Aeronautics	**Contributing Program:** Aeronautics Test					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Execute data measurement techniques and flow quality improvements at the Langley Research Center National Transonic Facility.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AR-14-11 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Aeronautics	**Contributing Program:** Aeronautics Test					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Use highly-detailed experimental and computer simulations to determine the potential of the truss-braced wing technology concept to enable reduced fuel use in transport aircraft.	9AT7 Green	10AT07 Green	AR-11-6 Green	AR-12-8 Green	AR-13-4 Green	AR-14-5 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: AR-16-3: Quantify the drag reduction benefit of boundary layer ingestion for a representative aircraft configuration.						
Contributing Theme: Aeronautics	**Contributing Program:** Advanced Air Vehicles (FY 2014: Fundamental Aeronautics)					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate Ultra High Bypass (UHB) propulsion systems can be integrated with Hybrid Wing Body (HWB) concepts to meet fuel burn and noise goals.	No API this fiscal year	10AT12 Yellow	AR-11-10 Green	AR-12-12 Green	AR-13-6 Green	AR-14-7 Green
Planned Future Performance						
For FY 2015: AR-15-3: Develop and analyze vehicle concepts with the appropriate technology suite to simultaneously meet fuel burn, community noise, and Landing and Take-off Nitrogen Oxides subsonic transport goals by the 2020-2025 timeframe.						
For FY 2016: No API this fiscal year						
Contributing Theme: Aeronautics	**Contributing Program:** Integrated Aviation Systems (FY 2014: Integrated Systems Research)					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Conduct a successful Project Formulation Review and establish an advanced composites consortium to accelerate the development and certification process for advanced composite structures.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AR-14-9 Yellow
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: AR-16-4: Complete Phase I activities and create a plan for Phase II to enable the project to reduce the timeline for development and certification of advanced composite structures.						
Contributing Theme: Aeronautics	**Contributing Program:** Advanced Air Vehicles (FY 2014: Integrated Systems Research)					

Explanation of Rating

NASA's Advanced Composites project focuses its research on accelerating the development, verification, and regulatory acceptance of advanced composite materials. The goal is to reduce the time it takes to get advanced composite materials from development, through certification, and to the market in an effort to maintain America's competitive advantage in the global aerospace industry. During FY 2014, the Advanced Composites project completed many but not all of the activities for establishing the Advanced Composites Consortium. As a result, NASA rated AR-14-9 yellow.

On May 28, 2014, the Advanced Composites project underwent a final Formulation Review covering fiscal years 2015 through 2018. The Associate Administrator for NASA's Aeronautics Research Mission Directorate (ARMD) gave the Advanced Composites project authority to proceed. The Formulation Authorization Document, authorizing project implementation, was signed. After reviewing the partnering approach, ARMD approved the Advanced Composites project to proceed with the Advanced Composites Consortium, with a condition that they engage an independent third party integrator to manage the consortium.

The Advanced Composites Consortium is designed to address and fund the research and technology development needs of NASA and industry related to certification processes, procedures, and tools to support the integration of advanced composite materials and structures into aeronautics vehicles. It includes NASA, other government agencies, industry, and academia. During FY 2015, NASA plans to formally establish the Advanced Composites Consortium with an agreed to Articles of Collaboration, which will complete the annual performance indicator.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Facilitate significant environmental and efficiency improvements through research on alternative jet fuel use and on hybrid gas-electric propulsion system concepts.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	2.1.4 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Aeronautics	**Contributing Program:** Multiple Programs (FY 2014: Fundamental Aeronautics)			

FY 2014 Performance Results

Alternative Fuel Effects on Contrails and Cruise Emissions (ACCESS) II flight testing, staged in FY 2014 from Palmdale, CA, was the latest in a series of ground and flight tests that began in 2009 to study emissions and contrail formation from new blends of aviation fuels that include biofuel from renewable sources. The ACCESS II campaign is a joint effort under the Fundamental Aeronautics Program involving NASA and international partners, including the German Aerospace Agency (DLR) and the National Research Council (NRC) of Canada.

ACCESS I testing, conducted in 2013, showed that the biofuel blends tested may substantially reduce emissions of black carbon, sulfates, and organics. The ACCESS II experiment gathered additional data confirming the results of ACCESS I, and contributed to ongoing studies about contrail formation.

Four research aircraft were involved in the ACCESS II campaign: DLR's Falcon 20-E5, NRC's CT-133, NASA's four-engine DC-8 flying laboratory, and NASA's HU-25C Guardian. Flying as high as 40,000 feet, the DC-8's four CFM56 engines burned a mix of different fuel blends (either traditional Jet A fuel or a 50-50 blend of Jet A and renewable alternative fuel of hydro processed esters and fatty acids produced from camelina plant oil), while the Falcon, Guardian, and CT-133 measured emissions and observed contrail formation from the DC-8.

Understanding the characteristics of burning alternative fuels could enable their widespread use as they become more readily available and cost competitive with conventional jet fuels. This research supports the strategic vision of NASA's Aeronautics Research Mission Directorate (ARMD), part of which is to enable the transition of the aviation industry to alternative fuels and low-carbon propulsion systems. As part of an international team involved in this research, NASA will share its findings with the 24 member nations that make up the International Forum for Aviation Research. DLR and NRC are participating members and NASA is the current chair.

As a promising technology for improving the efficiency of N+3 (research and development generation that is three generations beyond the current commercial transport fleet) aircraft designs, the Fundamental Aeronautics Program is investing in hybrid gas-electric propulsion system technologies. The program completed studies that resulted in a viable conceptual design for a superconducting generator, and work was begun to establish a superconductor AC loss facility at the Center for Advanced Power Systems at Florida State University. The generator concept established the feasibility of a fully superconducting electric generator to be used in a distributed propulsion aircraft configuration. This is a concept that would allow multiple electric motors to drive many distributed fans to be used in an ultra-efficient hybrid electric aircraft. Additionally, ARMD made a selection through the NASA Research Announcement process to begin contractual work on a low-emissions, fuel-flexible combustor.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Model and design a fully superconducting electric generator for novel aircraft propulsion applications.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AR-14-13 Green
Planned Future Performance						
For FY 2015: AR-15-4: Characterize gaseous and particulate cruise emissions of biofuel-blended jet fuels and effects of fuel sulfur during flight at cruise conditions.						
For FY 2016: AR-16-5: Develop a detailed conceptual design of a hybrid gas-electric propulsion system for a B737-class aircraft and assess its overall vehicle-level benefits in terms of noise, emissions, and energy consumption.						
Contributing Theme: Aeronautics	**Contributing Program:** Advanced Air Vehicles (FY 2014: Fundamental Aeronautics)					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: AR-16-6: Establish a process for originating, proposing, and selecting feasibility assessment research activities for the Convergent Aeronautics Solutions (CAS) Project.						
Contributing Theme: Aeronautics	**Contributing Program:** Transformative Aeronautics Concepts					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Significantly increase the ability to anticipate and resolve potential safety issues and to predict the health and robustness of aviation systems.	4.1.1.1 Green	4.1.1.1 Green	4.1.1.1 Green	2.1.5 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Aeronautics	**Contributing Program:** Multiple Programs (FY 2014: Aviation Safety)			

FY 2014 Performance Results

NASA's Aviation Safety Program has partnered with engine manufacturers and other government agencies to conduct Vehicle Integrated Propulsion Research (VIPR) testing with the goal of advancing the commercialization and acceptance of propulsion health management technologies. This partnership provides a means to test and evaluate emerging health management technologies on a commercial engine, incorporating new sensors directly on the engine and evaluating advances in engine diagnostics. During FY 2014, NASA and its partners engaged in detailed planning for VIPR testing scheduled for FY 2015. This will be the third in a series of three tests related to propulsion health management that began in FY 2011, and will include planned ingestion of volcanic ash into an aircraft-mounted engine during a ground test.

Current methods of lightning protection for composites result in unwanted additional weight. The Aviation Safety Program is conducting research on a new, multifunctional lightning strike protection method for aircraft that can also detect and diagnose damage to composite structures. Since composites do not have the conductivity of aluminum, manufacturers embed a metal mesh (typically aluminum or copper) on the surface of the composite material. The mesh adds conductivity that helps prevent lightning from creating catastrophic damage, but it also adds weight. The new method applies a "SansEC," ("sans" (without) electric connection) sensor, made of a thin, lightweight copper foil, to an aircraft surface, forming a "Smart Skin" layer. The program conducted research in FY 2014 that demonstrated the new method successfully meets lightning strike protection requirements with less weight than current methods and also detected and diagnosed damage scenarios, including delamination, punctures, and rips.

During the past 20 years, the aviation industry has documented more than 200 incidents where turbofan jet engines have lost power during high-altitude flights. For many of these events, the aircraft were flying in the vicinity of heavy storm clouds, but with little activity showing on the weather radar at their flight altitude. NASA is part of an international team working to improve aviation safety by analyzing high altitude ice crystals using a specially equipped French Falcon 20 aircraft. The primary goal of the FY 2014 flight campaign, conducted in Darwin, Australia, during its summer months, was to collect data on the characteristics of weather known to produce high ice water icing conditions. This research will help the aviation community to better understand

the meteorological conditions that cause high concentrations of crystals in certain areas, advancing the development of technologies that may someday be able to detect the presence of ice crystals or lessen their effects in flight.

The Aviation Safety Program's data mining research focuses on identifying precursors that often provide an early indication of an impending event that could pose a safety concern. Accurate and timely identification of precursor conditions will be a key capability in the drive toward more real-time, system-wide safety assurance. The program has developed a suite of capable algorithms that can look for precursors among different data types, across thousands of recorded flights. In FY 2014, the program developed methods to improve the reliability of predicting future events through identification of specific precursors. In particular, the program examined connections between overspeeds and underspeeds (potential safety events) and data patterns occurring earlier in the flight (precursors). The program also expanded its capability to identify unusual events (anomalies) in radar track data. This class of algorithms will be instrumental in developing broader system-wide safety capabilities that consider both onboard and air traffic data.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Conduct a ground-based demonstration of a wireless sensor that provides lightning protection and can detect and diagnose damage in composite structures.	No API this fiscal year	No API this fiscal year	No API this fiscal year	AR-12-1 Green	No API this fiscal year	AR-14-1 Green
Planned Future Performance						
For FY 2015: AR-15-5: Demonstrate that aircraft engine diagnostic systems that rely on advanced sensors can detect faults and hazards between maintenance inspections.						
For FY 2016: No API this fiscal year						
Contributing Theme: Aeronautics	**Contributing Program:** Transformative Aeronautics Concepts (FY 2014: Aviation Safety)					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: AR-16-7: Mature the safety risk assessment module as a step towards validating and demonstrating this assessment module and as part of advanced technology demonstrations.						
Contributing Theme: Aeronautics	**Contributing Program:** Airspace Operations and Safety					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	4.2.1.1 Green	4.2.1.1 Green	4.2.1.1 Green	2.1.6 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Aeronautics	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

Integration of Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS) will represent a significant step in enabling more automation throughout the NAS. The Integrated Systems Research Program's UAS-NAS project contributes capabilities that reduce technical barriers related to the safety and operational challenges associated with enabling routine UAS civil access to the NAS. During FY 2014, the UAS-NAS project conducted an integrated human-in-the-loop simulation as a precursor to a series of flight test campaigns, which will progressively increase the complexity of UAS integration testing that will occur over the next two years. The test campaign had three objectives. The first was to evaluate air traffic controllers' acceptance of UAS maneuvers performed in order to remain "well-clear" of other traffic. The second objective was to examine the effects of advanced traffic displays and tools on the ability of UAS pilots to maintain well clear of traffic. Finally, the test collected performance metrics to determine the interoperability of the UAS sense-and-avoid algorithms and current-collision-avoidance algorithms. This testing featured use of the project's operationally relevant environment called Live Virtual Constructive-Distributed Environment (LVC-DE). For this test campaign, the LVC-DE included a proof-of-concept UAS ground control station and virtual traffic. UAS pilots and air traffic controllers participated as test subjects. This was a significant step in the development of findings and data associated with the sense-and-avoid, communications, and human system integration performance requirements and guidelines.

The National Research Council of the National Academies published a report titled "Autonomy Research for Civil Aviation: Toward a New Era of Flight" in FY 2014 as a result of the Aeronautics Research Mission Directorate's (ARMD's) request to convene a committee to develop a national research agenda for autonomy in civil aviation. Increasingly autonomous (IA) systems, characterized by their ability to perform more complex mission-related tasks with substantially less human intervention for more extended periods of time, sometimes at remote distances, are being envisioned for aircraft and air traffic management and other ground-based elements of the NAS. The report recommended a national research agenda in autonomy, including eight high priority research projects that should be executed by those in government, industry, and academia who are involved in the research, development, manufacture, certification, and regulation of IA technologies. In a parallel effort to the National Academies study, ARMD established an inter-center autonomy study team (ICAST) to assess what technical challenge areas NASA should address. ARMD combined the results of the ICAST effort with the National Academies study and will use them to further define research efforts related to autonomy in aviation.

Through development and testing, the Aviation Safety Program is addressing key challenges associated with verification and validation methods essential for meeting the extremely high levels of safety required for flight-critical systems operating in the Next Generation Air Transportation System (NextGen). During FY 2014, the program demonstrated use of one of these advanced software assurance techniques, compositional verification, through testing of an entire flight control system. Compositional verification enables a system-level software safety assessment by breaking down the system into component parts and examining the safety properties of each of those components. Formal methods such as compositional verification allow for more comprehensive and more efficient verification and validation of flight-critical systems.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate use of an advanced software technique to verify the safety of a complex aircraft or ground automation software system.	No API this fiscal year	10AT01 Green	AR-11-1 Green	AR-12-2 Green	AR-13-2 Green	AR-14-2 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Aeronautics	**Contributing Program:** Aviation Safety					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Conduct a human-in-the-loop (HiTL) simulation where unmanned aircraft are mixed with manned aircraft and subjected to a range of test conditions.	No API this fiscal year	No API this fiscal year	No API this fiscal year	AR-12-13 Green	AR-13-7 Green	AR-14-8 Green
Planned Future Performance						
For FY 2015: AR-15-7: Deliver data, analysis, and recommendations based on integrated simulations and flight tests to the RTCA Special Committee on Minimum Operational Performance Standards (MOPS) for Unmanned Aircraft Systems to support preliminary MOPS development.						
For FY 2016: AR-16-8: Deliver data, analysis, and recommendations based on two integrated flight test series with simulated traffic and live vehicles to the RTCA Special Committee on Minimum Operational Performance Standards (MOPS) for Unmanned Aircraft Systems to support development of the final MOPS.						
Contributing Theme: Aeronautics	**Contributing Program:** Integrated Aviation Systems (FY 2014: Integrated Systems Research)					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AR-13-9 Green	None
Planned Future Performance						
For FY 2015: AR-15-6: Implement Automatic Dependent Surveillance-Broadcast Out (ADS-B Out) capability on select flight test support aircraft to enable the testing of operational design solutions that enable safe, efficient growth in global operations.						
For FY 2016: No API this fiscal year						
Contributing Theme: Aeronautics	**Contributing Program:** Integrated Aviation Systems					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: AR-16-9: Complete Unmanned Aircraft Systems Traffic Management initial prototype to enable safe and efficient low altitude airspace operations and conduct initial tests.						
Contributing Theme: Aeronautics	**Contributing Program:** Airspace Operations and Safety					

Strategic Objective 2.2

Advance knowledge of Earth as a system to meet the challenges of environmental change, and to improve life on our planet.

Lead Office
Earth Science Division (ESD), Science Mission Directorate (SMD)

Goal Leader
Dr. Michael Freilich, Director, Earth Science Division

Contributing Programs
Earth Science Research Program, Earth Systematic Missions Program, Earth System Science Pathfinders Program, Earth Science Multi-Mission Operations Program, Applied Sciences Program, Earth Science Technology Program.

Budget for Strategic Objective 2.2

	Actual	Enacted	Requested	Notional			
Budget Authority (in $ millions)	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$1,825	---	$1,947	$1,967	$1,988	$2,009	$2,027

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
Further understanding of the Earth as a system to meet the challenges of environmental change, as well as continued improvement of life on this planet.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- Appropriate and sufficient strategies are in place to achieve the strategic objective.
- Risks and challenges have been identified and are being addressed appropriately. ESD faces the same challenges as other SMD Divisions, as outlined in the 2014 Science Plan.
- ESD has identified and is taking advantage of a range of opportunities.

FY 2014 achievements included the following:

- The launch of the Global Precipitation Measurement (GPM) mission.
- The launch of the Orbiting Carbon Observatory (OCO)-2 mission.

- Completed the Preliminary Design Reviews for the Cyclone Global Navigation Satellite System (CYGNSS) and Gravity Recovery and Climate Experiment (GRACE) Follow-On missions.
- Completed the Soil Moisture Active Passive (SMAP) Instrument Thermal Vacuum Test.
- Conduct Key Decision Point (KDP)-Bs for Tropospheric Emissions: Monitoring of Pollution (TEMPO) and Surface Water Ocean Topography (SWOT).
- Conduct the Sustainable Land Imaging Architecture Study.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

NASA has instituted several process improvements designed to achieve greater insight into project performance, including contractor cost performance. Specifically, NASA has enhanced project formulation by clarifying expected project maturities, instituting Formulation Agreements, implementing Joint Confidence Levels, establishing tools to provide schedule health checks, and requiring the use of Earned Value Management on projects with a lifecycle cost estimate greater than $20 million, including in-house development work.

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan. Additional information on strategies, challenges, implementation, and program-specific detail is available in the NASA 2014 Science Plan, as well as the 2010 report, "Responding to the Challenge of Climate and Environmental Change." ESD is pursuing several opportunities to mitigate or address challenges, such as developing new and innovative ways of making Earth observations via the Earth Venture solicitations, utilizing the International Space Station (ISS) as a platform for observations, and continuing to make technology investments through the Earth Science Technology Program.

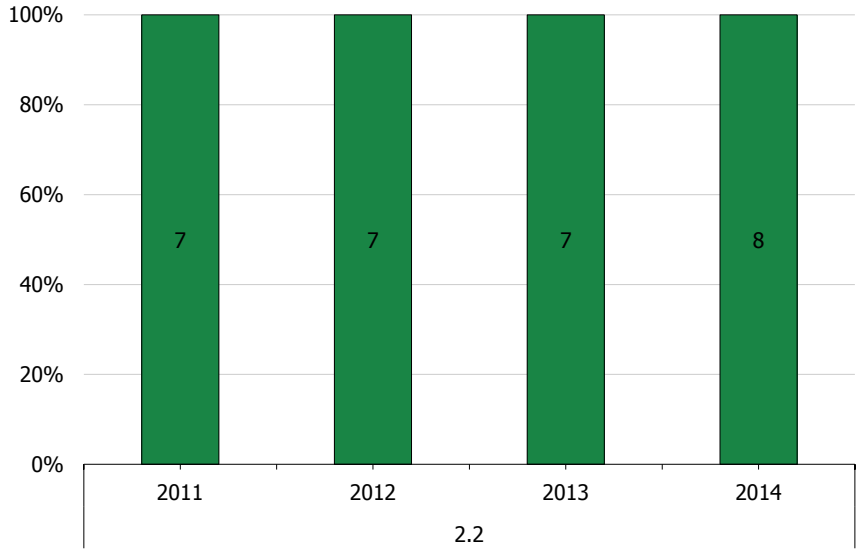
Next Steps in FY 2015

- Prepare to launch SMAP in FY 2015.
- Continue development of the Stratospheric Aerosol and Gas Experiment (SAGE)-III.
- Select Earth Venture Instrument (EVI)-2 and Earth Venture Sub-Orbital (EVS)-2 investigations.
- Release Announcements of Opportunity for the third Earth Venture Instrument (EVI-3) and the second Earth Venture small Mission (EVM-2).

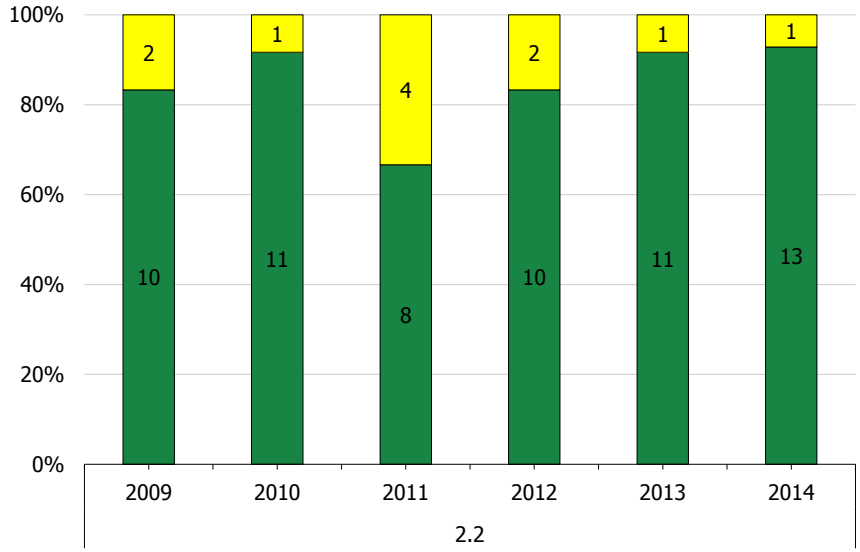
FY 2014 Performance Measures

Strategic Objective 2.2: Advance knowledge of Earth as a system to meet the challenges of environmental change, and to improve life on our planet.							
Performance Goal 2.2.1: 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.	Performance Goal 2.2.2: Demonstrate progress in improving the capability to predict weather and extreme weather events.	Performance Goal 2.2.3: Demonstrate progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.	Performance Goal 2.2.4: 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.	Performance Goal 2.2.5: 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.	Performance Goal 2.2.6: 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.	Performance Goal 2.2.7: Further the use of Earth system science research to inform decisions and provide benefits to society.	Performance Goal 2.2.8: By December 2017, launch at least five missions in support of Strategic Objective 2.2.
Annual Performance Indicators							
• ES-14-1: 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.	• ES-14-3: Demonstrate planned progress in improving the capability to predict weather and extreme weather events.	• ES-14-6: Demonstrate planned progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.	• ES-14-7: 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.	• ES-14-9: 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.	• ES-14-11: 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.	• ES-14-12: Advance at least 25 percent of decision-support projects one Applications Readiness Level. • ES-14-14: Maintain a high level of customer satisfaction, as measured by exceeding the most recently available Federal government average rating of the Customer Satisfaction Index.	• ES-14-10: Deliver the Ice, Cloud, and Land Elevation Satellite (ICESat)-2 flight lasers. • ES-14-18: Complete the Gravity Recovery and Climate Experiment (GRACE) Follow-On mission Preliminary Design Review (PDR). • ES-14-2: Complete the Orbiting Carbon Observatory (OCO)-2 observatory testing. • ES-14-4: Launch the Global Precipitation Measurement (GPM) mission. • ES-14-5: Complete Cyclone Global Navigation Satellite System (CYGNSS/EV-2) Preliminary Design Review (PDR). • ES-14-8: Complete Soil Moisture Active Passive (SMAP) Instrument Thermal Vacuum Test.

Performance Goal Ratings for Strategic Objective 2.2, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 2.2, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	2.1.1.1 Green	2.1.1.1 Green	2.1.1.1 Green	2.2.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Earth Science Subcommittee of the NASA Advisory Council Science Committee determined in October 2014 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 2014.

In the past year, NASA researchers and partners completed a series of field studies aimed at providing an unprecedented view of air pollution. DISCOVER-AQ, or Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality, targets the information needed to improve use of satellite observations to diagnose near-surface air quality. The most recent study was performed over the Denver/Northern Front Range region of Colorado during July through August 2014.

The Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) flew its 500th science flight hour during May 2014, successfully completing its Baseline Science Investigation Requirements, quantifying correlations between atmospheric concentrations of carbon dioxide and methane with surface-atmosphere carbon fluxes and surface state control variables (soil moisture, freeze-thaw state, inundation state, surface soil temperature) and elucidating the sensitivities of Arctic carbon cycle processes to climate change.

Studies quantifying the emissions of atmospheric trace gases and reconciling top-down and bottom-up approaches were a focus of research. Stratospheric-Troposphere Processes and their Role in Climate (SPARC), a core project of the World Climate Research Programme, released their recently completed report, "Lifetimes of Stratospheric Ozone-Depleting Substances, Their Replacements, and Related Species," in March 2014.

Researchers studied the quantification of tropical emissions of methane from fires using tropospheric methane and carbon monoxide data from the Aura Tropospheric Emission Spectrometer (TES), and new carbon monoxide profile measurements from the Terra satellite Measurements of Pollution in the Troposphere (MOPITT) instrument, together with the Goddard Earth Observing System (GEOS)-Chem model, to estimate methane emissions from fires in Indonesia. The El Niño related Indonesian fires increased the tropical distribution of atmospheric methane relative to 2005, indicating that tropical biomass burning can compensate for expected decreases in tropical wetland methane emissions from reduced rainfall during El Niño, as found in previous studies.

Research showed that stratospheric water vapor variations play an important role in the evolution of Earth's climate. Analysis of Aura Microwave Limb Sounder observations showed that stratospheric water vapor increased with tropospheric temperature, implying the existence of a stratospheric water vapor feedback. The authors estimated that the strength of this feedback in a chemistry–climate model would be a significant contributor to overall

climate sensitivity. One-third of this feedback comes from increases in water vapor entering the stratosphere through the tropical tropopause layer, with the rest coming from increases in water vapor entering through the extratropical tropopause.

Thirty years since the discovery of the Antarctic ozone hole and 27 years after the signing of the Montreal Protocol on Substances that Deplete the Ozone Layer, a review of the scientific understanding of the ozone hole and understanding of the polar atmosphere was published. It found that the worldwide response to the discovery was fast, but the recovery in ozone is slow. Ground and satellite observations show that chlorine levels in the troposphere and stratosphere are decreasing and model projections suggest that the ozone will return to 1980 levels sometime between 2050 and 2070.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 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.	9ES1 Green	10ES01 Green	ES-11-1 Green	ES-12-1 Green	ES-13-1 Green	ES-14-1 Green
Planned Future Performance						
For FY 2015: ES-15-1: 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.						
For FY 2016: ES-16-1: 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.						
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in improving the capability to predict weather and extreme weather events.	2.1.2.1 Green	2.1.2.1 Green	2.1.2.1 Green	2.2.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Earth Science Subcommittee of the NASA Advisory Council Science Committee determined in October 2014 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 2014.

After nearly 17 years in space, the Tropical Rainfall Measuring Mission (TRMM) is almost out of fuel, but it will continue to operate as it slowly descends toward Earth's surface. TRMM's long-term precipitation datasets are vital for improving weather forecasting models and detecting hurricanes, tornadoes, and extremes in precipitation patterns. In 2014, NASA scientists developed a prototype online extreme precipitation monitoring system, demonstrated a strong relationship between changes in global rainfall patterns and the Hadley cell, characterized the precipitation features and annual rainfall patterns in the Central Andes, and updated the oceanic precipitation rate and its zonal distribution.

A modeling study developed a coupled land surface and routing model and real-time global flood estimation tool using TRMM precipitation data. A widely used land surface model, the Variable Infiltration Capacity (VIC) model, was coupled with a newly developed hierarchical dominant river tracing-based runoff-routing model to form the Dominant river tracing-Routing Integrated with VIC Environment (DRIVE) model. DRIVE serves as the new core of the real-time Global Flood Monitoring System (GFMS). The GFMS uses real-time satellite-based precipitation to derive flood-monitoring parameters for the latitude band between the 50th parallel north and 50th parallel south at a relatively high spatial (approximate to 12 kilometers) and temporal (three-hourly) resolution.

At the NASA Short-term Prediction Research and Transition (SPoRT) center, extensive progress was made to transition new, cutting-edge satellite datasets and products from the suite of instruments on the Suomi-National Polar-orbiting Partnership satellite and precipitation estimates in data void regions from the Global Precipitation Measurement (GPM) mission. The number of operational weather entities using data from NASA research instruments has grown substantially, and includes national forecast centers for hurricanes and continental and marine weather prediction, as well as disaster response agencies using imagery and power outage products to assist in the assessment of and monitoring the recovery from devastating tropical storms and tornadoes.

The NASA GPM mission Integrated Precipitation and Hydrology Experiment (IPHEx) took place in the Appalachian Mountains of southwestern North Carolina from May 1 to June 15, 2014. GPM IPHEx partners included Duke University and the National Oceanic and Atmospheric Administration Hydrometeorological Testbed. Overarching campaign objectives included the improvement of satellite-based remote sensing algorithms of clouds and precipitation over mountainous terrain, and evaluation and further development of associated data products for use in hydrologic applications, such as flood prediction. To achieve these objectives, an extensive set of airborne and ground-based instruments were deployed and operated under occasional overpasses of GPM constellation satellite platforms.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate planned progress in improving the capability to predict weather and extreme weather events.	9ES7 Green	10ES04 Green	ES-11-5 Green	ES-12-4 Green	ES-13-3 Green	ES-14-3 Green
Planned Future Performance						
For FY 2015: ES-15-2: Demonstrate planned progress in improving the capability to predict weather and extreme weather events.						
For FY 2016: ES-16-2: Demonstrate planned progress in improving the capability to predict weather and extreme weather events.						
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Demonstrate progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.	2.1.3.1 Green	2.1.3.1 Green	2.1.3.1 Green	2.2.3 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Earth Science Subcommittee of the NASA Advisory Council Science Committee determined in October 2014 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 2014.

Research published in Science used Landsat satellite data to map global forest loss and gain from 2000 to 2012. Results from time-series analysis of over 650,000 Landsat images showed the tropics as the only climatic domain to exhibit a trend of increasing forest loss. Brazil's well-documented reduction in deforestation was offset by increasing forest losses in Indonesia, Malaysia, Paraguay, Bolivia, Zambia, Angola, and elsewhere. The intensive forestry and logging practiced within subtropical forests resulted in the highest rates of forest change globally. Boreal forest loss, due largely to fire and forest harvest, was second to that in the tropics in absolute and proportional terms. These results depict, for the first time, a globally consistent and locally relevant record of forest change at the landscape scale.

Discoveries made during the 2011-2012 Impacts of Climate on the EcoSystems and Chemistry of the Arctic Pacific Environment (ICESCAPE) field campaign were documented in a 2014 special issue of Deep-Sea Research II. Blooms of phytoplankton (microscopic marine plants) beneath the ice were observed to extend from the sea-ice edge to 72 miles into the ice pack. During the campaign, scientists punched through three-foot-thick sea ice to find waters richer in these phytoplankton than any other ocean region on Earth. Researchers have estimated that phytoplankton production under the ice in parts of the Arctic could be up to 10 times higher than in the nearby open ocean. Fast-growing phytoplankton consume large amounts of carbon dioxide. The papers in the special issue explore the potential mechanisms and causes of the bloom, and conclude that scientists will have to reassess the amount of carbon dioxide entering the Arctic Ocean through biological activity if the under-ice blooms turn out to be common. The finding reveals a new consequence of the Arctic's warming climate and provides an important clue to understanding the impacts of a changing climate and environment on the Arctic Ocean and its ecology.

Urban ecosystems are receiving growing attention, both as settings for major land cover and land use change impacts, as well as for their role in global carbon emissions. Coastal cities are also of great interest with respect to the impacts of sea level rise and extreme hydrological events. A variety of findings have been reported. A NASA project on mega-urban changes and impacts reported that traditional approaches using satellite optical and spectral sensors may have underestimated the urbanization of Beijing and other megacities in China. This group found SeaWinds scatterometer data helpful for evaluating changes in urban systems, including a recent study of groundwater vulnerability that makes use of relationships between land use changes and groundwater contamination.

Research under NASA's Carbon Monitoring System (CMS) program continued to focus on using satellite and airborne remote sensing capabilities to prototype key data products to meet U.S. carbon monitoring, reporting, and verification needs. The CMS project developed one of the most advanced carbon data assimilation systems in the world that integrates satellite and surface observations related to anthropogenic, oceanic, terrestrial, and atmospheric carbon. In the past year, new CMS studies have gotten underway using commercial off-the-shelf airborne measurement methodologies in support of international Reducing Emissions from Deforestation and forest Degradation (REDD), and REDD+ projects in Indonesia, Mexico, Peru, and Brazil, as well as carbon sequestration, management, and state-level mapping projects within the United States.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Demonstrate progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.	9ES10 Green	10ES07 Green	ES-11-7 Green	ES-12-6 Green	ES-13-5 Green	ES-14-6 Green
Planned Future Performance						
For FY 2015: ES-15-3: Demonstrate progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.						
For FY 2016: ES-16-3: Demonstrate progress in detecting and predicting changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle.						
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	2.1.4.1 Green	2.1.4.1 Green	2.1.4.1 Green	2.2.4 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Earth Science Subcommittee of the NASA Advisory Council Science Committee determined in October 2014 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 2014.

NASA's water and energy cycle focus area has continued to enable better assessment and management of water quality and quantity to accurately predict how the global water cycle evolves in response to climate change. The NASA Energy and Water cycle Study (NEWS) produced an accounting of the water cycle using the latest assessment of various water budget terms. This study was able to close the annual global budget, including transfers between land and ocean basins, with less than a 10 percent water residual. On a more granular basis (monthly or individual continents), the uncertainties were larger, roughly 20 percent. Unlike most previous attempts at this exercise, NEWS relied primarily on satellite observations and further improved the resolution of the water budget, both temporally (monthly instead of annual) and spatially (continental and oceanic basins).

Within the water budget, one of the main sources of uncertainty is the flux of water from the ocean surface to the atmosphere. NASA investigators have worked together with the Sea Flux project to make numerous advances. This year's work has helped extend Sea Flux datasets back to 1987. One advance this year has been the identification and correction of a problem with the Earth incidence angle corrections applied to different satellite datasets, reducing errors and creating a more consistent long-term data record of evaporation rates. Another achievement of NASA researchers is creating the ocean evaporation product with a three-hour temporal resolution. This has enabled better inspection of the diurnal cycle and opened new areas of investigation to improve understanding of this process.

A recent study demonstrated the power of satellite observations for regions without in situ measurements by using Landsat thematic mapper images over three different rivers to achieve estimates within 20 to 30 percent of river gage estimates. Consistent with Surface Water Ocean Topography (SWOT)

mission's planned instrumentation, research developed an algorithm to solve the shallow water equations to estimate river water surface elevation and slope. The algorithm was tested for the River Severn and for known inflow and provided relatively accurate discharge (10 percent root-mean-square error, or RMSE, which calculates differences between the value predicted by a model and the observed value). For unknown inflows, RMSE increased to 36 percent. This algorithm's performance could be improved with known river parameters (e.g., bathymetry and roughness). NASA scientists combined satellite altimetric observations and land surface modeling to estimate discharge at 475 virtual stations in the Amazon. They tested approaches using a subset of these stations to inform the modeling system to get estimates of discharge at the other virtual stations. This work provides evidence that the SWOT discharge algorithm may result in better estimates of river discharge when combined with land-surface modeling than either piece independently.

Studies of extreme events have led to progress in the assessment of how the global water cycle evolves in response to climate change. NEWS initiated innovative integration projects focused on the role of clouds in the climate system, the origins and dynamics of the 2012 midwestern drought, and the 2002 global climate shift. As an example, two studies have traced back the role of the land surface in drought and differentiated this from larger-scale patterns. These two studies are able to point to alternative monthly leading indicators for possible drought onset, as well as areas of study that might improve drought forecasting.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 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.	9ES13 Green	10ES09 Green	ES-11-9 Green	ES-12-8 Green	ES-13-7 Green	ES-14-7 Green
Planned Future Performance						
For FY 2015: ES-15-4: 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.						
For FY 2016: ES-16-4: 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.						
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: ES-15-5: Complete Aquarius mission success criteria.						
For FY 2016: No API this fiscal year						
Contributing Theme: Earth Science	**Contributing Program:** Earth System Science Pathfinder					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: ES-16-6: Complete Soil Moisture Active Passive (SMAP) mission success criteria.						
Contributing Theme: Earth Science	**Contributing Program:** Earth Systematic Missions					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	2.1.5.1 Green	2.1.5.1 Green	2.1.5.1 Green	2.2.5 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Earth Science Subcommittee of the NASA Advisory Council Science Committee determined in October 2014 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 2014.

The largest uncertainty in projections of future sea-level change results from the potentially changing ice discharge from Antarctica. Basal ice-shelf melting induced by a warming ocean has been identified as a major cause for additional ice flow across the grounding line, which is the boundary between the floating ice shelf and the ice resting on bedrock. NASA-funded investigators estimated the uncertainty range of future ice discharge from Antarctica by combining uncertainty in the climatic forcing, the oceanic response, and the ice-sheet model response. The resulting uncertainty range for the historic Antarctic contribution to global sea-level rise from 1992 to 2011 agreed with the observed contribution for this period.

Ice shelves play key roles in stabilizing Antarctica's ice sheets, maintaining its high albedo and returning freshwater to the Southern Ocean. Improved datasets of ice shelf draft and underlying bathymetry are important for assessing ocean–ice interactions and modeling ice response to climate change. The long, narrow Abbot Ice Shelf, south of Thurston Island, produces a large volume of meltwater, but is close to being in overall mass balance. While the ice shelf is presently in equilibrium, recent work indicates sensitivity to changes in characteristics of the ocean surface and deep waters.

Mass loss from the Greenland ice sheet contributes significantly to present sea level rise. High meltwater runoff is responsible for half of Greenland's mass loss. Surface melt has been spreading and intensifying in Greenland, with the highest ever surface area melt and runoff recorded in 2012. How surface meltwater reaches the ocean, and how fast it does so, however, is poorly understood. The bed topography beneath the Greenland ice sheet controls the flow of ice and its discharge into the ocean. Outlet glaciers move through a set of narrow valleys. The detailed geometry of these valleys is poorly known, especially along the southern coasts. As a result, the contribution of the Greenland ice sheet and its glaciers to sea-level change in the coming century is uncertain. Recent work has inferred ice thickness and bed topography along the entire periphery of the Greenland ice sheet at an unprecedented level of spatial detail and precision. They detected widespread ice-covered valleys that extend significantly deeper below sea level and farther inland than

previously thought. Their findings imply that the outlet glaciers of Greenland, and the ice sheet as a whole, are probably more vulnerable to ocean thermal forcing and peripheral thinning than inferred previously.

During the past year the NASA Ocean Biogeochemical Model was completely integrated into the Goddard Earth Observing System (GEOS)-5 modeling system, providing a representation of ocean biology in a coupled ocean framework. This will allow expanded investigations of feedbacks between ocean biology and the physical Earth system. Added to the modeling system was the GEOS-Chem grid-independent chemical transport model (CTM). This addition creates a strong link between the GEOS-Chem chemical transport model, which is developed and maintained at Harvard University, and the Goddard Modeling and Assimilation Office at the Goddard Space Flight Center. The advantage of such an arrangement is that it allows for rapid synchronization of code developments pioneered at Harvard into the GEOS-5 system, providing benefits for all users. In addition, a new component was added to the system on emissions.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 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.	9ES15 Green	10ES11 Green	ES-11-11 Green	ES-12-10 Green	ES-13-9 Green	ES-14-9 Green
Planned Future Performance						
For FY 2015: ES-15-7: 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.						
For FY 2016: ES-16-7: 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.						
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	2.1.6.1 Green	2.1.6.1 Green	2.1.6.1 Green	2.2.6 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

The Earth Science Subcommittee of the NASA Advisory Council Science Committee determined in October 2014 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 2014.

NASA's Space Geodesy project completed a site selection study for the deployment of new multi-technique core geodetic observatories: McDonald Observatory in Texas was selected for the western U.S. site; and NASA's Kokee Park Geophysical Observatory on Kauai and the Haleakala Observatory on Maui were selected for the Pacific stations, expected to be operational in 2017. At its most basic, geodesy is the science of where things are on Earth, as determined using techniques such as Global Positioning System (GPS) imaging. The International Earth Rotation and Reference Systems Service certified

the Jet Propulsion Laboratory as an International Terrestrial Reference Combination Center, one of only three worldwide and the only one in the United States.

The Advanced Rapid Imaging and Analysis (ARIA) project is a joint Jet Propulsion Laboratory–California Institute of Technology effort to automate synthetic aperture radar (SAR) and GPS imaging capabilities to improve scientific understanding of and the response to natural hazards. Through its collaboration with the Italian Space Agency (ASI), the ARIA team is implementing its cloud-enabled SAR analysis data system using COSMO-Skymed (CSK) X-band SAR data. The collaboration and data access agreements with ASI enabled the ARIA team to provide a near real time damage proxy map for Typhoon Haiyan, the storm that devastated the Philippines in November 2013; and a flood map for areas of Sardinia hard hit by Cyclone Cleopatra. One of the largest earthquake response activities in the last year was for the magnitude 6.0 South Napa earthquake on August 24, 2014, where the team provided GPS measurements of the coseismic deformation within two days and a coseismic interferogram within four days after the earthquake. After its release, field teams used the CSK coseismic interferogram immediately to identify additional surface ruptures.

The Uninhabited Aerial Vehicle (UAV) SAR project was called to aid rapid response efforts shortly after the magnitude 6.0 South Napa earthquake in determining faulting and assessing damage to levees and aqueducts. The project was able to rapidly initiate the data processing so that Repeat-Pass Interferometric (RPI) browse images were delivered of all flown flight lines within 48 hours post-flight and began delivering refined interferometric products within four days post-flight. With browse data, the project was able to provide information to the California Department of Water Resources about crustal deformation along the San Pablo Bay shoreline quickly in support of their levee response activities and to the U.S. Geological Survey to direct their ground survey crews. The UAVSAR images showed slip details around the epicenter of the quake in areas where the X-band CSK data released earlier in the week were unusable. The results agreed with ground surveys of movement on the main fault and provided more comprehensive information about the movement that occurred across the region.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 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.	9ES17 Green	10ES13 Green	ES-11-15 Green	ES-12-14 Green	ES-13-11 Green	ES-14-11 Green
Planned Future Performance						
For FY 2015: ES-15-8: 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.						
For FY 2016: ES-16-8: 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.						
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Further the use of Earth system science research to inform decisions and provide benefits to society.	2.1.7.1 Green	2.1.7.1 Green	2.1.7.1 Green	2.2.7 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

NASA's Applied Sciences Program (ASP) 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 ASP projects improves quality of life and strengthens the economy. Following are some examples from FY 2014:

- The U.S. Environmental Protection Agency integrated Aura, Aqua, and Terra satellite data into the AirNow air-quality system, which health officials use to alert the public about hazardous pollution.
- A project with the National Marine Fisheries Service applied Jason-2, Aqua, and other satellite data of sea surface height, temperature, and chlorophyll to reduce the number of collisions between whales and ships.
- The California Department of Water Resources applied Moderate Resolution Imaging Spectroradiometer (MODIS), Visible Infrared Imaging Radiometer Suite (VIIRS), and Terrestrial Observation and Prediction System (TOPS) products in irrigation management trials for crops, decreasing total applied water for tested crops by over 30 percent relative to standard practice.
- The National Oceanic and Atmospheric Administration used MODIS data to monitor and assess the intensity of harmful algal blooms in Lake Erie, assisting the State of Ohio and the City of Toledo in the issuance of urgent do-not-drink water notices.
- A research sensor that NASA transferred to the U.S. Forest Service made its debut in wildfire operations.

In addition, NASA used the vantage point of space to support the response to numerous national and international disasters:

- NASA supported the international response to Typhoon Haiyan in Southeast Asia, providing information products on rainfall, power outages, and building damage assessments derived from satellite data.
- NASA provided data from the Suomi National Polar-orbiting Partnership (NPP), Terra, Aqua, Tropical Rainfall Measuring Mission (TRMM), and other satellites for numerous wildfires, floods, earthquakes, volcanic ash, landslides, tornadoes, and other disasters.
- In the SERVIR program (managed jointly with the U.S. Agency for International Development), a project enabled the application of Jason-2 data to improve a flood forecasting system in Bangladesh; the Institute of Water Modelling in Bangladesh extended its forecasts from three to eight days.

Of the 41 projects tracked, ASP advanced 24 projects, or 59 percent, at least one application readiness level, an index is used 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 apply Earth science data, included over 350 people in 81 projects, and it introduced a new track to involve military veterans in projects. Applied Sciences' training endeavor on remote sensing for professionals held its first-ever course on ecosystems and land management and conducted numerous training programs, reaching hundreds of people in the United States and globally.

ASP also engaged the applications community in planning for upcoming satellites. Together with the Centers for Disease Control and Prevention, the Soil Moisture Active Passive (SMAP) mission held a workshop on public health, disease exposure, and future applications of SMAP data. The Ice, Cloud, and Land Elevation Satellite (ICESat)-2 team held a joint vegetation tutorial with Landsat 8, as well as a sea ice applications meeting with the Naval Research Laboratory.

Finally, ASP continued its efforts to communicate the potential applications of Earth observations for societal and economic benefits. ASP received a Gold Hermes Creative Award from the Association of Marketing and Communication Professionals, and the host of the SERVIR Hub in Kathmandu received the Esri Special Achievement in GIS (geographic information system) award in 2014.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Advance at least 25 percent of decision-support projects one Applications Readiness Level.	9ES18 Green	10ES14 Green	ES-11-16 Green	ES-12-15 Green	ES-13-12 Green	ES-14-12 Green
Planned Future Performance						
For FY 2015: ES-15-9: Advance at least 25 percent of decision-support projects one Applications Readiness Level.						
For FY 2016: ES-16-9: Advance at least 35 percent of Earth science applications projects one Applications Readiness Level.						
Contributing Theme: Earth Science	**Contributing Program:** Applied Sciences					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Maintain a high level of customer satisfaction, as measured by exceeding the most recently available Federal government average rating of the Customer Satisfaction Index.	9ES20 Green	10ES16 Green	ES-11-18 Green	ES-12-17 Green	ES-13-14 Green	ES-14-14 Green
Planned Future Performance						
For FY 2015: ES-15-10: Maintain a high level of customer satisfaction, as measured by exceeding the most recently available Federal government average rating of the American Customer Satisfaction Index.						
For FY 2016: ES-16-10: Maintain a high level of customer satisfaction, as measured by exceeding the most recently available Federal government average rating of the American Customer Satisfaction Index.						
Contributing Theme: Earth Science	**Contributing Program:** Earth Science Multi-Mission Operations					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
By December 2017, launch at least five missions in support of Strategic Objective 2.2.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	2.2.8 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Earth Science	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

In FY 2014, NASA remained on target to achieve this performance goal by launching two missions that support Strategic Objective 2.2:

- NASA and the Japanese Aerospace Exploration Agency (JAXA) launched the Global Precipitation Measurement (GPM) mission on February 27, 2014. GPM is an international satellite mission to provide next-generation observations of rain and snow worldwide every three hours. The GPM mission will help advance the understanding of Earth's water and energy cycles and improve the forecasting of extreme events that cause natural disasters.

- NASA launched the Orbiting Carbon Observatory (OCO)-2 on July 2, 2014. OCO-2 will collect the first space-based measurements of atmospheric carbon dioxide with the precision, resolution, and coverage needed to characterize its sources and sinks and quantify their variability over the seasonal cycle. OCO-2 measurements will help scientists to understand the sources of carbon dioxide emissions and how they are changing over time, and to construct better models to predict how much carbon dioxide sinks will be able to absorb in the future.

In addition, NASA is on schedule with its plans to launch three more missions that will support this performance goal:

- The Soil Moisture Active Passive (SMAP) mission, scheduled for launch in FY 2015, will provide global measurements of soil moisture and freeze/thaw approximately every three days, which can be used to develop improved flood prediction and drought monitoring capabilities, among other potential applications. In December 2013, NASA completed a thermal vacuum test of the SMAP instrument to qualify it for operation in space. The thermal vacuum chamber simulated the temperature and pressure environment the instrument will encounter in space.
- The Cyclone Global Navigation Satellite System (CYGNSS) mission, scheduled for launch in FY 2016, will make frequent and accurate measurements of ocean surface winds throughout the life cycle of tropical storms and hurricanes, with the goal of improving hurricane forecasting. In January 2014, NASA completed the Preliminary Design Review (PDR) for CYGNSS. The PDR ensures that the designs and systems selected are appropriate to the program's needs, that the risks have been assessed, and that the estimated cost and schedule baselines are acceptable.
- The Gravity Recovery and Climate Experiment (GRACE) Follow-On mission, scheduled for launch in FY 2017, is a partnership between NASA and the German Research Centre for Geosciences, and will measure variations in gravity over Earth's surface, producing a new map of the gravity field every 30 days. In January 2014, NASA completed the PDR for the GRACE Follow-On mission.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Deliver the Ice, Cloud, and Land Elevation Satellite (ICESat)-2 flight lasers.	9ES16 Yellow	10ES12 Green	ES-11-14 Yellow	ES-12-13 Yellow	ES-13-10 Yellow	ES-14-10 Yellow
Planned Future Performance						
For FY 2015: ES-15-13: Complete the Ice, Cloud, and Land Elevation Satellite (ICESat)-2 Spacecraft Readiness for Integration Review.						
For FY 2016: ES-16-13: Complete Ice, Cloud, and Land Elevation Satellite-2 (ICESat-2) Mission Operations Center (MOC) final release.						
Contributing Theme: Earth Science	**Contributing Program:** Earth Systematic Missions					

Explanation of Rating

From spring 2013 through spring 2014, the Ice, Cloud, and Land Elevation Satellite (ICESat)-2 project conducted a thorough, end-to-end reassessment of all the instrument and mission systems and subsystems, while at the same time continuing to make critical design and developmental progress on those systems. ICESat-2 passed its Critical Design Review in February 2014, completing the FY 2013 annual performance indicator. These activities culminated in a comprehensive rebaseline of the project, which was reviewed by the Science Mission Directorate in March 2014 and approved by the NASA Agency Program Management Council in May 2014. During the rebaseline process, it became clear that the flight lasers for ICESat-2 would be delayed; delivery is now scheduled for the second half of FY 2015. Due to this delay, NASA rated ES-14-10 yellow for FY 2014.

Since NASA codified the rebaseline, work on all ICESat-2 systems is progressing according to plan. This performance shortfall did not affect NASA's overall progress towards achieving Performance Goal 2.2.8.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the Gravity Recovery and Climate Experiment (GRACE) Follow-On mission Preliminary Design Review (PDR).	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ES-14-18 Green
Planned Future Performance						
For FY 2015: ES-15-15: Complete the Gravity Recovery and Climate Experiment (GRACE) Follow-On mission Critical Design Review (CDR).						
For FY 2016: ES-16-15: Complete the Gravity Recovery and Climate Experiment (GRACE) Follow-On mission instrument delivery to integration and test (I&T).						
Contributing Theme: Earth Science	**Contributing Program:** Earth Systematic Missions					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the Orbiting Carbon Observatory (OCO)-2 observatory testing.	9ES2 Green	10ES22 Green	ES-11-3 Yellow	ES-12-2 Green	No API this fiscal year	ES-14-2 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Earth Science	**Contributing Program:** Earth System Science Pathfinder					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Launch the Global Precipitation Measurement (GPM) mission.	9ES8 Yellow	10ES06 Green	ES-11-6 Yellow	ES-12-5 Yellow	ES-13-4 Green	ES-14-4 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Earth Science	**Contributing Program:** Earth Systematic Missions					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete Cyclone Global Navigation Satellite System (CYGNSS/EV-2) Preliminary Design Review (PDR).	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ES-13-2 Green	ES-14-5 Green
Planned Future Performance						
For FY 2015: ES-15-11: Complete the Cyclone Global Navigation Satellite System (CYGNSS) Critical Design Review (CDR).						
For FY 2016: ES-16-11: Complete Cyclone Global Navigation Satellite System (CYGNSS) Unit 1 thermal vacuum test.						
Contributing Theme: Earth Science	**Contributing Program:** Earth System Science Pathfinder					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete Soil Moisture Active Passive (SMAP) Instrument Thermal Vacuum Test.	9ES14 Green	10ES10 Yellow	ES-11-10 Yellow	ES-12-9 Green	ES-13-8 Green	ES-14-8 Green
Planned Future Performance						
For FY 2015: ES-15-12: Launch the Soil Moisture Active Passive (SMAP) mission.						
For FY 2016: No API this fiscal year						
Contributing Theme: Earth Science	**Contributing Program:** Earth Systematic Missions					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: ES-15-14: Complete the Surface Water and Ocean Topography (SWOT) mission Ka-band Radar Interferometer (KaRIn) antenna Preliminary Design Review (PDR).						
For FY 2016: ES-16-14: Complete the Surface Water and Ocean Topography (SWOT) mission Preliminary Design Review (PDR).						
Contributing Theme: Earth Science	**Contributing Program:** Earth Systematic Missions					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: ES-16-16: Complete NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NI-SAR) High Capacity Data Storage Subsystem Preliminary Design Review (PDR).						
Contributing Theme: Earth Science	**Contributing Program:** Earth Systematic Missions					

Strategic Objective 2.3

Optimize Agency technology investments, foster open innovation, and facilitate technology infusion, ensuring the greatest national benefit.

Lead Office
Office of the Chief Technologist (OCT)

Goal Leader
Jim Adams, Deputy Chief Technologist, OCT

Contributing Programs
FY 2014: Partnership Development and Strategic Integration
FY 2015 and 2016: Agency Technology and Innovation

Budget for Strategic Objective 2.3

	Actual	Enacted	Requested	Notional			
Budget Authority (in $ millions)	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$31	---	$33	$33	$33	$33	$33

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
The Agency's technology portfolio will be optimized by aligning technology investments across mission directorates, minimizing duplication, and producing critical capabilities that support missions and longer-term national needs. Open innovation will thrive within NASA. Transfer of NASA technology to U.S. companies will be maximized.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- Sufficient strategies are in place to achieve the strategic objective.
- Tools and processes for technology portfolio tracking, analysis, and optimization are being maintained.
- OCT recently initiated the update of the NASA Technology Roadmaps.
- OCT is using innovative approaches such as prizes and challenges to facilitate problem solving and promote technology transfer.

FY 2014 achievements included the following:

- NASA's Quick Launch Licensing tool went live in November 2013, making obtaining licenses for a select number of technologies easy, quick and inexpensive.
- NASA is reaching new audiences for licensing opportunities and using crowd sourcing to help find secondary applications for NASA technologies. In FY 2014, OCT engaged with a start-up company called Marblar to enable crowdsourcing new product ideas using NASA technologies. The initiative gives Marblar's online community access to portions of NASA's portfolio of patented technologies, so they can use the technologies as an idea incubator. NASA received 25 market summaries and one license.
- The Asteroid Grand Challenge announced several new partnerships in FY 2014.
- In April 2014, a new software catalog (http://software.nasa.gov) made available NASA-developed code for public use.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

Next Steps in FY 2015

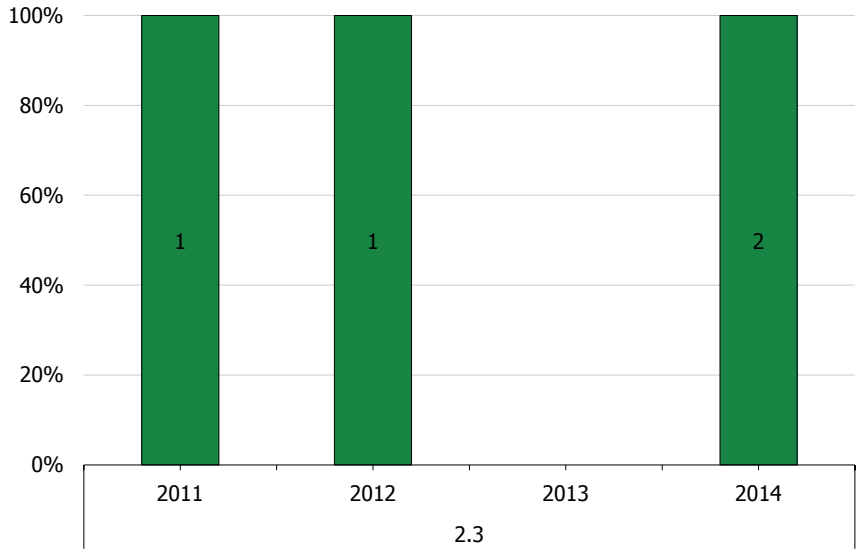
Work in progress in FY 2015 includes:

- Optimize Agency Technology Investments
  - NASA will release the draft NASA Technology Roadmaps for public review and comment and prepare them for an independent review.
  - NASA will develop the draft Strategic Technology Investment Plan (STIP) that provides prioritization of the technologies within the NASA Technology Roadmaps and release the draft for Agency review.
  - TechPort will be released to the public.
- Facilitate Technology Transfer
  - NASA Centers will engage with university business schools for technology marketing assessments to discover new ways that industry can apply for NASA technologies, and receive draft business plans on how NASA technologies can be adopted by industry.
  - NASA will develop new guidelines to increase access for students to use NASA technologies, such as allowing simple non-negotiated licenses with no upfront fees, should students choose to pursue commercial applications.
- Foster Open Innovation
  - The Asteroid Grand Challenge will continue to explore partnership opportunities to expand the potential for citizens to contribute to the challenge and will begin at least two mission proofs or pilot projects for measurable contributions to the challenge.

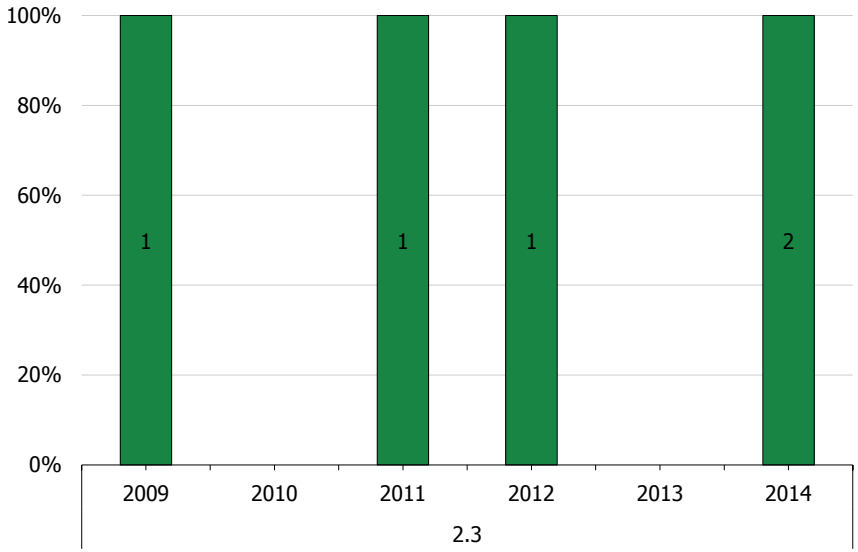
FY 2014 Performance Measures

Strategic Objective 2.3: Optimize Agency technology investments, foster open innovation, and facilitate technology infusion, ensuring the greatest national benefit.	
Performance Goal 2.3.1: Implement the five-year Strategic Plan to improve the ability to transfer NASA-developed technologies.	Performance Goal 2.3.2: Implement a process that enables the Agency to define and lead the Agency Grand Challenge.
Annual Performance Indicators	
• ST-14-8: The Agency will develop and implement two innovative methods for technology licensing.	• ST-14-9: Establish at least two new "open innovation" mechanisms that leverage external support for the Asteroid Grand Challenge.

Performance Goal Ratings for Strategic Objective 2.3, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 2.3, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.
For 2013, there were no performance measures associated with Strategic Objective 2.3.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Implement the five-year Strategic Plan to improve the ability to transfer NASA-developed technologies.	3.4.1.2 Green	3.4.1.2 Green	No PG this fiscal year	2.3.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Space Technologies	**Contributing Program:** Agency Technology and Innovation (FY 2014 and 2015: Partnership Development and Strategic Integration)			

FY 2014 Performance Results

NASA is on track to complete this performance goal. In FY 2014, NASA executed three new licensing approaches and one new strategy to build partnerships for technology development and transfer.

During the fiscal year, NASA developed and implemented innovative methods for technology licensing. This included the following activities:

- The NASA QuickLaunch licensing portal now has approximately 100 technologies, marketed on the Technology Transfer (T2) Portal. This resulted in six licenses in FY 2014.
- The Agency engaged with the product development startup Marblar for crowdsourcing new product ideas. The initiative gives Marblar's online community access to portions of NASA's portfolio of patented technologies, so they can use the technologies as an idea incubator. Through the partnership, NASA received 25 market summaries and one license. NASA began another crowdsourcing initiative with Edison Nation, an online service that will help NASA showcase technologies and patents available to industry and the public. Edison Nation will focus on a single technology at a time around which innovators can solicit ideas.
- NASA engaged with Startup Quest Florida for entrepreneurship training using NASA technologies. NASA executed two patent licenses and won a Federal Laboratory Consortium regional award for excellence in technology transfer for this work.
- NASA engaged with the Center for Innovation in Arlington, TX, to function as its partnership intermediary for licensing and partnership agreement opportunities.

NASA's technology transfer efforts also support the cross-agency priority goal on Lab-To-Market.

More information is available at NASA's Office of the Chief Technologist Web site.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: The Agency will develop and implement two innovative methods for technology licensing.	9IPP2 Green	No API this fiscal year	ST-11-14 Green	ST-12-14 Green	No API this fiscal year	ST-14-8 Green
Planned Future Performance						
For FY 2015: ST-15-7: Each Center will engage with at least one university business school for technology marketing assessments and encouragement of technology application.						
For FY 2016: ST-16-7: Streamline, augment, and automate intellectual property and license portfolio management through a licensee monitoring system.						
Contributing Theme: Space Technologies	**Contributing Program:** Agency Technology and Innovation (FY 2014 and 2015: Partnership Development and Strategic Integration)					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: ST-16-9: Develop an initiative to encourage and track infusion of NASA-developed technology into NASA missions, and pilot the initiative at three or more NASA Centers.						
Contributing Theme: Space Technologies	**Contributing Program:** Agency Technology and Innovation					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Implement a process that enables the Agency to define and lead the Agency Grand Challenge.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	2.3.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Space Technologies	**Contributing Program:** Agency Technology and Innovation (FY 2014 and 2015: Partnership Development and Strategic Integration)			

FY 2014 Performance Results

Grand Challenges are ambitious, but achievable, goals on a national or global scale that capture the imagination and demand advances in innovation and breakthroughs in science and technology. They require high-impact, multi-disciplinary collaborations and public-private partnerships in areas where the Federal Government alone cannot achieve the desired outcome. A Grand Challenge consists of both NASA organized and non-NASA organized activities, potentially including a number of challenges, to make progress toward the goal.

In FY 2014, NASA began drafting an execution plan that will help guide any new future Grand Challenge development.

The Asteroid Grand Challenge is focused on finding all asteroid threats to Earth and planning for those threats. NASA is on track to complete this performance goal, an important first step to conducting the Grand Challenge.

NASA signed two Space Act Agreements. The first, with SpaceGAMBIT, is leading to externally funded citizen asteroid projects, some of which build on International Space Apps projects. The other is with Slooh, a robotic telescope service, which already has done a broadcast on an asteroid flyby, generating a major trend in social media.

In addition to these Space Act Agreements, NASA also executed a cooperative agreement with the Expert and Citizen Assessment of Science and Technology, a consortium of respected universities, science centers and non-governmental organizations, to conduct two in-person and one online forum for facilitated dialogues with the public to determine the benefits and risks associated with the Asteroid Initiative.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Establish at least two new "open innovation" mechanisms that leverage external support for the Asteroid Grand Challenge.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ST-14-9 Green
Planned Future Performance						
For FY 2015: ST-15-8: Establish at least two new "open innovation" mechanisms that leverage external support for the Asteroid Grand Challenge.						
For FY 2016: ST-16-8: Establish at least two new "open innovation" mechanisms that leverage external support for the Asteroid Grand Challenge.						
Contributing Theme: Space Technologies	**Contributing Program:** Agency Technology and Innovation (FY 2014 and 2015: Partnership Development and Strategic Integration)					

Strategic Objective 2.4

Advance the Nation's STEM education and workforce pipeline by working collaboratively with other agencies to engage students, teachers, and faculty in NASA's missions and unique assets.

Lead Office
Office of Education

Goal Leader
Dr. Roosevelt Johnson, Deputy Associate Administrator for Education

Contributing Programs
Aerospace Research & Career Development Program, STEM Education and Accountability Program

Budget for Strategic Objective 2.4

Budget Authority (in $ millions)	Actual FY 2014	Enacted FY 2015	Requested FY 2016	Notional FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$117	---	$89	$90	$92	$93	$94

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
Through collaboration with other agencies and prominent positions on federal science, technology, engineering, and mathematics (STEM) committees, over the next 10 years NASA will achieve increased impact on the Nation's STEM education and workforce pipeline through facilitation of STEM based internships, scholarships, and fellowships and the contribution of unique NASA mission and asset driven institutional engagement, experiential learning, and professional development opportunities.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- Education is making progress on portfolio alignment and other strategic indicators.
- Improvement areas include participation on national/federal strategic committees and full leverage and implementation of Education's new organizational structure.

FY 2014 achievements included the following:

- The Office of Education signed a Space Act Agreement with Destination Imagination, Inc., a nonprofit organization providing project-based educational programs in the United States and abroad, to foster creativity and innovation among K-12 students that enables adding NASA space exploration and innovation content to Destination Imagination's programs and activities.
- NASA Education formalized a long-standing collaboration with a federal partner through a non-reimbursable agreement with the National Institute for Food and Agriculture, a sub agency within the United States Department of Agriculture. Under the private 4-H Council, the first activity in this five-year agreement was to help prepare and launch the 2014 National Youth Science Day on October 8, 2014. Hundreds of thousands of youths in the United States and abroad participated in this youth-led science experiment as part of 4-H National Youth Science Day.
- NASA and the Department of Education entered into a reimbursable Space Act Agreement that ran from fall 2013 through winter 2014. The agreement aligned with Federal priorities to increase and sustain youth and public engagement in STEM and supported STEM objectives and activities within Department of Education's 21st Century Community Learning Center (21CCLC) program. NASA customized online STEM challenges and associated curriculum materials aligned to 21CCLC objectives and implemented them in Colorado, Michigan, and Virginia. NASA and the Department of Education are using the results from this pilot activity to draft a framework for other federal collaborations with 21CCLC.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

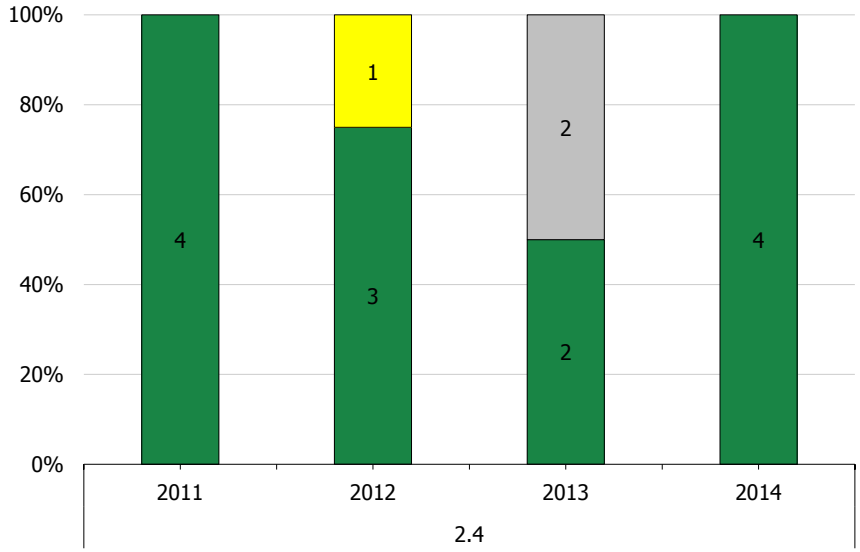
Next Steps in FY 2015

- Continuation of Education's portfolio alignment with the Committee on Science, Technology, Engineering, and Math Education (CoSTEM) and Administration's priorities.
- 600,000 elementary and secondary students will participate in NASA STEM engagement activities.
- 80,000 educators will participate in NASA-supported professional development, research, and internships that use NASA-unique STEM content.

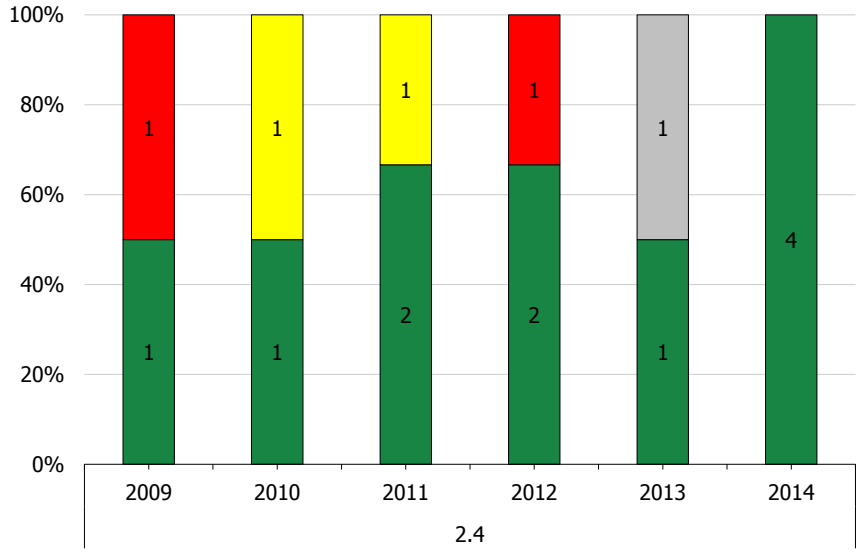
FY 2014 Performance Measures

Strategic Objective 2.4: Advance the Nation's STEM education and workforce pipeline by working collaboratively with other agencies to engage students, teachers, and faculty in NASA's missions and unique assets.			
Performance Goal 2.4.1: Assure that students participating in NASA higher education projects are representative of the diversity of the Nation.	Performance Goal 2.4.2: Continue to support STEM educators through the delivery of NASA education content and engagement in educator professional development opportunities.	Performance Goal 2.4.4: 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.	Performance Goal 2.4.5: Continue to provide opportunities for learners to engage in STEM education engagement activities that capitalize on NASA-unique assets and content.
Annual Performance Indicators			
• ED-14-1: Provide significant, direct student awards in higher education to (1) students across all institutional levels and types (as defined by the U.S. Department of Education); (2) racially or ethnically underrepresented students, (3) women, and (4) persons with disabilities at percentages that meet or exceed the national percentages for these populations, as determined by the most recent, publicly available data from the U.S. Department of Education's National Center for Education Statistics for a minimum of two of the four categories.	• ED-14-6: 250,000 educators participate in NASA-supported professional development, research, and internships that use NASA-unique STEM content.	• ED-14-5: Maintain the NASA Museum Alliance and/or other STEM education strategic partnerships in no fewer than 30 states, U.S. territories, and/or the District of Columbia.	• ED-14-8: One million elementary and secondary students participate in NASA STEM engagement activities.

Performance Goal Ratings for Strategic Objective 2.4, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 2.4, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Assure that students participating in NASA higher education projects are representative of the diversity of the Nation.	5.1.2.1 Green	5.1.2.1 Yellow	5.1.2.1 White	2.4.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Education	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

NASA's performance in diversity is examined across ethnicity, race, gender, and disability status. NASA Education is on target to complete this performance goal given we provided 3,165 significant, direct student awards in higher education to students across all institutional categories and levels in FY 2013. The FY 2013 population of significant awardees also exceeded the national science, technology, engineering, and mathematics (STEM) enrollment percentages for the demographic categories of racially and ethnically underrepresented student participants and female student participants.

NASA student participants receiving significant awards attend institutions that represent all institutional categories (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 Education provided 26 percent of its awards to racially and ethnically underrepresented student participants, compared to 8 percent for the national average; and 40 percent of its awards to women, compared to 39 percent for the national average. However, NASA is below the national enrollment percentage for persons with disabilities. NASA provided 0.6 percent of its awards to persons with disabilities, compared to 11 percent for the national average.

NASA's offices, mission directorates, and Centers are collaborating to implement an Agency-wide approach to STEM education. As NASA integrates its STEM Education projects and activities into a more focused portfolio, NASA Education will develop new awards to support the consolidation efforts. Due to various awards still completing their award period, in 2015 NASA may just be on par with national STEM averages, as opposed to current performance of exceeding national STEM averages in certain diversity areas. Moving forward, NASA plans to fund open competitions focused on NASA Education's performance goals. NASA Education will also strategically fund activities to support the Committee on Science, Technology, Engineering, and Math Education (Co-STEM) priorities and NASA Education business lines.

NASA Education's efforts also support the cross-agency priority goal on STEM (science, technology, engineering, and mathematics) Education.

Note: NASA Education reports on prior year data. Data are based on the 2013–2014 academic calendar.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Provide significant, direct student awards in higher education to (1) students across all institutional levels and types (as defined by the U.S. Department of Education); (2) racially or ethnically underrepresented students, (3) women, and (4) persons with disabilities at percentages that meet or exceed the national percentages for these populations, as determined by the most recent, publicly available data from the U.S. Department of Education's National Center for Education Statistics for a minimum of two of the four categories.	9ED3 Red	10ED03 Yellow	ED-11-1 Yellow	ED-12-1 Red	ED-13-1 White	ED-14-1 Green
Planned Future Performance						
For FY 2015: ED-15-1: Provide significant, direct student awards in higher education to (1) students across all institutional categories and levels (as defined by the U.S. Department of Education); (2) racially or ethnically underrepresented students, (3) women, and (4) persons with disabilities at percentages that meet or exceed the national percentages for these populations, as determined by the most recent, publicly available data from the U.S. Department of Education's National Center for Education Statistics for a minimum of two of the four categories.						
For FY 2016: ED-16-1: Provide significant, direct student awards in higher education to (1) students across all institutional categories and levels (as defined by the U.S. Department of Education); (2) racially or ethnically underrepresented students, (3) women, and (4) persons with disabilities at percentages that meet or exceed the national percentages for these populations, as determined by the most recent, publicly available data from the U.S. Department of Education's National Center for Education Statistics for a minimum of two of the four categories.						
Contributing Theme: Education	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Continue to support STEM educators through the delivery of NASA education content and engagement in educator professional development opportunities.	6.1.1.1 Green	6.1.1.1 Green	6.1.1.1 White	2.4.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Education	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

NASA uses multiple methods to engage educators (e.g., direct face-to-face activities, online learning tools). NASA Education is on target to achieve this performance goal. Through NASA Education, 305,733 educators have participated in NASA-supported activities. This number includes 6,128 pre-service and 285,667 in-service K-12 educators, 11,037 informal educators, and 2,901 higher education faculty. Professional development efforts include synchronous and asynchronous online workshops and in-person workshops lasting from one day to two weeks. Distance learning opportunities have been increased to reach a more diverse geographic population. NASA Education is also working with partners, to include the U.S. Department of Education's 21st Century Community Learning Center, 100Kin10 (i.e., a network dedicated to the Nation's need for 100,000 science, technology, engineering, and math teachers in 10 years), and the National Science Teachers Association, to increase the reach of NASA educational content.

NASA Education's efforts also support the cross-agency priority goal on STEM (science, technology, engineering, and mathematics) Education.

Note: NASA Education reports on prior year data. Data are based on the 2013–2014 academic calendar.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 250,000 educators participate in NASA-supported professional development, research, and internships that use NASA-unique STEM content.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	ED-14-6 Green
Planned Future Performance						
For FY 2015: ED-15-2: Engage with at least 80,000 educators in NASA-supported professional development, research, and internships that use NASA-unique STEM content.						
For FY 2016: ED-16-2: Engage with at least 80,000 educators in NASA-supported professional development, research, and internships that use NASA-unique STEM content.						
Contributing Theme: Education	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	6.4.1.1 Green	6.4.1.1 Green	6.4.1.1 Green	2.4.4 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Education	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

NASA is on target to achieve this performance goal by providing NASA-unique content through different education institutions. NASA Education supports a diverse portfolio of programs that enhance education efforts on space exploration, aeronautics, space science, Earth science, and microgravity. These partnerships, maintained through the NASA Museum Alliance, result in strategic collaboration between science, technology, engineering, and mathematics (STEM) formal and informal education providers, such as science centers, planetariums, museums, aquariums, zoos, nature centers, parks and observatories, federal and non-federal NASA Visitor Centers and affiliates, and Challenger Centers. The Museum Alliance, which has organizations in 52 U.S. states and territories, will extend an existing, free-of-charge NASA STEM content facilitation membership service to long-time partners in NASA education, such as the Science Engineering Mathematics and Aerospace Academy (SEMAA). SEMAA uses content from all NASA mission directorates to increase the participation of historically underserved K-12 youth in STEM areas. SEMAA is located at community colleges; minority-serving higher education institutions; high schools, middle schools, and elementary schools; and science centers and museums in urban and rural cities throughout the United States.

NASA Education's efforts also support the cross-agency priority goal on STEM Education.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Maintain the NASA Museum Alliance and/or other STEM education strategic partnerships in no fewer than 30 states, U.S. territories, and/or the District of Columbia.	9ED11 Green	10ED10 Green	ED-11-9 Green	ED-12-9 Green	ED-13-5 Green	ED-14-5 Green
Planned Future Performance						
For FY 2015: ED-15-4: Maintain the NASA Museum Alliance and/or other STEM education strategic partnerships in no fewer than 30 states, U.S. territories, and/or the District of Columbia.						
For FY 2016: ED-16-4: Maintain the NASA Museum Alliance and/or other STEM education strategic partnerships in no fewer than 30 states, U.S. territories, and/or the District of Columbia.						
Contributing Theme: Education	**Contributing Program:** Multiple Programs					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Continue to provide opportunities for learners to engage in STEM education engagement activities that capitalize on NASA-unique assets and content.	6.1.2.2 Green	6.1.2.2 Green	6.1.2.2 Green	2.4.5 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Education	**Contributing Program:** Multiple Programs			

FY 2014 Performance Results

NASA Education conducted approximately 1,200 individual K-12 indirect and direct interactive events in FY 2013, when the last full cycle of data was available. These events leveraged NASA-unique resources, personnel, content, and facilities, and reached 1,020,528 elementary and secondary students in NASA STEM engagement activities. Interactive events included: experiential learning opportunities for youth at NASA Centers or events at NASA Education partner facilities with NASA content; design challenges with live mentoring from NASA scientists and engineers; professional development opportunities for the Nation's K-12 STEM educators; and other opportunities.

NASA Education's efforts also support the cross-agency priority goal on STEM Education.

Note: NASA Education reports on prior year data. Data are based on the 2013–2014 academic calendar.

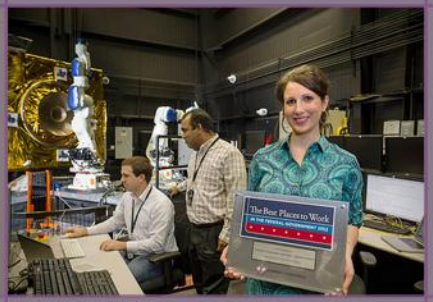
Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: One million elementary and secondary students participate in NASA STEM engagement activities.	No API this fiscal year	No API this fiscal year	ED-11-5 Green	ED-12-5 Green	No API this fiscal year	ED-14-8 Green
Planned Future Performance						
For FY 2015: ED-15-5: Engage with at least 600,000 elementary and secondary students in NASA STEM activities.						
For FY 2016: ED-16-5: Engage with at least 750,000 elementary and secondary students in NASA STEM activities.						
Contributing Theme: Education	**Contributing Program:** Multiple Programs					

4
Strategic
Objectives

Strategic Goal 3

Serve the American public and accomplish our Mission by effectively managing our people, technical capabilities, and infrastructure.

22
Performance
Goals

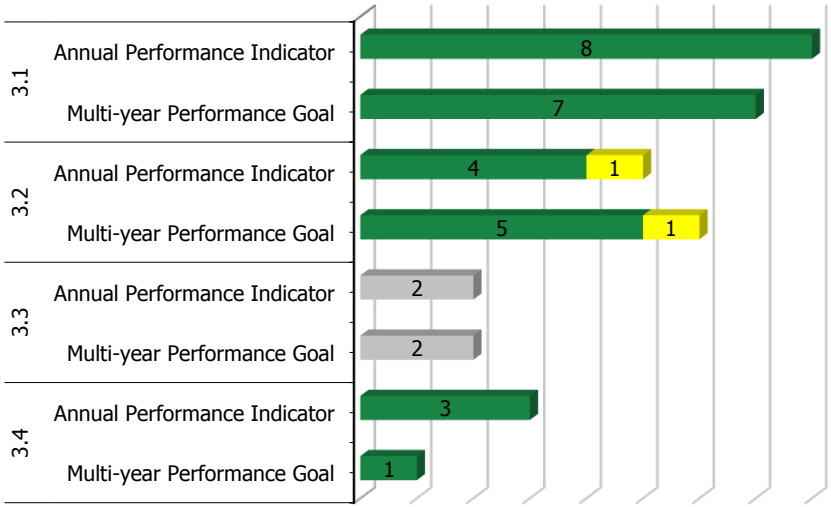


37
Annual
Performance
Indicators

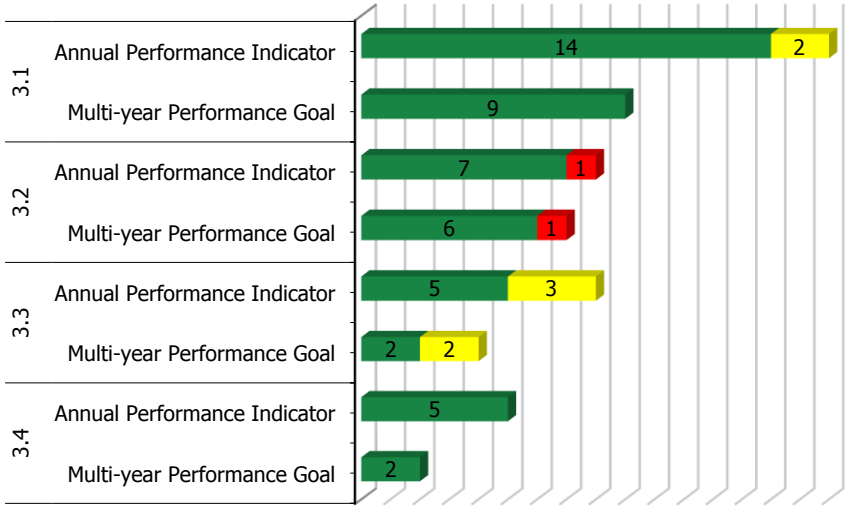
Strategic Goal 3: Serve the American public and accomplish our Mission by effectively managing our people, technical capabilities, and infrastructure.			
Strategic Objective 3.1: Attract and advance a highly skilled, competent, and diverse workforce, cultivate an innovative work environment, and provide the facilities, tools, and services needed to conduct NASA's missions.	Strategic Objective 3.2: Ensure the availability and continued advancement of strategic, technical, and programmatic capabilities to sustain NASA's Mission.	Strategic Objective 3.3: Provide secure, effective, and affordable information technologies and services that enable NASA's Mission.	Strategic Objective 3.4: Ensure effective management of NASA programs and operations to complete the mission safely and successfully.
FY 2014 Performance Goals			
• 3.1.1: Define and build diverse workforce skills and competencies needed for the Agency's technology development and deep space exploration. • 3.1.2: Advance a workplace environment that affords equal employment opportunities (EEO) to all employees and takes proactive diversity and inclusion efforts. • 3.1.3: Promote equal opportunity compliance and encourage best practices among NASA grant recipient institutions. • 3.1.4: Between 2012 and 2016, support the demolition and elimination of obsolete and unneeded facilities. • 3.1.5: Manage coordination of NASA's international and interagency activities in conjunction with the NASA mission directorates. • 3.1.6: Achieve savings for the Agency through acquisition reforms. • 3.1.7: Ensure that NASA continues progress towards implementing statutory or Executive Order targets and goals reflected in its annual Sustainability Plan. • 3.1.8: Enhance reach and effectiveness of programs and projects that engage the public. • 3.1.9: Manage coordination of advisory committees' (NASA Advisory Committee and Aerospace Safety Advisory Panel) recommendations to the NASA Administrator.	• 3.2.1: Review the current state of the NASA test capabilities, known test requirements and test requests, and revise the Master Plan as needed. • 3.2.2: Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches. • 3.2.3: By 2014, launch two functionally identical Tracking and Data Relay Satellite (TDRS) spacecraft in geosynchronous orbits to replenish the Tracking and Data Relay Satellite System (TDRSS) constellation. • 3.2.4: By FY 2016, replace or upgrade obsolete and unsustainable systems of the Tracking and Data Relay Satellite System (TDRSS) Ground Segment at the White Sands Complex (WSC). • 3.2.5: By FY 2018, replace aging Deep Space Network (DSN) 70-meter antenna at Canberra Deep Space Communications Complex (CDSCC). • 3.2.6: Prioritize and complete launch and range complex modernization studies and projects to sustain government and commercial capabilities at the Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS). • 3.2.7: Ensure the strategic availability and maintenance of facilities that are necessary to meet the long-term needs and requirements of the Agency.	• 3.3.1: Enhance NASA's information security posture through implementation of automated security and privacy tools and technologies. • 3.3.2: Identify viable alternatives to support Federal and Agency mobility goals, supporting Work from Anywhere (WFA). • 3.3.3: Consolidate and centralize the management of information technology (IT) enterprise services for end user services, communications, and enterprise applications. • 3.3.4: By 2015, reduce the number of data centers to 22.	• 3.4.1: 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. • 3.4.2: Implement the policies, procedures and oversight to continuously improve the probability of technical and programmatic mission success.

Summary of Performance for Strategic Goal 3

Comparison of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2013



Comparison of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2014



Summary of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2013

Strategic Goal 3					
Lead	**Objective**	**PGs**		**APIs**	
MSD	3.1	7		8	
HEOMD	3.2	5	1	4	1
MSD	3.3	2		2	
MSD	3.4	1		3	
	Total	16		18	
	Summary	81% Green		83% Green	
		6% Yellow		6% Yellow	
		13% White		11% White	

Summary of Ratings for Performance Goals and Annual Performance Indicators by Strategic Objective, FY 2014

Strategic Goal 3					
Lead	**Objective**	**PGs**		**APIs**	
MSD	3.1	9		14	2
HEOMD	3.2	6	1	7	1
MSD	3.3	2	2	5	3
MSD	3.4	2		5	
	Total	22		37	
	Summary	86% Green		84% Green	
		9% Yellow		14% Yellow	
		5% Red		3% Red	

Strategic Objective 3.1

Attract and advance a highly skilled, competent, and diverse workforce, cultivate an innovative work environment, and provide the facilities, tools, and services needed to conduct NASA's missions.

Lead Office
Mission Support Directorate (MSD)

Goal Leader
Richard Keegan, NASA Associate Deputy Administrator

Contributing Programs
Center Management and Operations, Agency Management, Institutional Construction of Facilities (CoF), Environmental Compliance and Restoration

Budget for Strategic Objective 3.1

Budget Authority (in $ millions)	Actual FY 2014	Enacted FY 2015	Requested FY 2016	Notional FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$2,778	---	$2,900	$2,944	$2,988	$3,033	$3,078

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
NASA has a diverse workforce with the right balance of skills and talents and provides an inclusive work environment in which employees with varying perspectives, education levels, skills, life experiences, and backgrounds work together and are fully engaged in NASA's mission. NASA's institutional capabilities enable it to provide the day-to-day operations required to support and achieve its missions.

Update of Progress Toward Strategic Objective
NASA, in consultation with the Office of Management and Budget, has highlighted this strategic objective as a focus area for improvement.

The NASA 2014 Strategic Review found that:

- NASA has achieved success in diversity and equal opportunity, workforce satisfaction and engagement, communications, and sustainability.
- Strategies in place are mostly sufficient to meet the strategic objective. Continued attention and resources are needed to address challenges associated with maintenance, aging infrastructure, and environmental compliance.
    - About 82 percent of NASA's infrastructure and facilities are beyond their constructed design life. Aging infrastructure from the Apollo era is costly to maintain and, in some cases, poses risk to mission operations. To address challenges associated with aging infrastructure, NASA is aggressively managing its facilities portfolio to consolidate and modernize into fewer, more efficient and sustainable facilities.

- NASA has achieved some success in consolidating facilities, reducing energy costs, and demolishing unneeded infrastructure and will continue to use these tools in managing its facilities portfolio.
- NASA will continue to prioritize and triage maintenance and repair work to prevent or minimize facility failures and impacts to missions.

FY 2014 achievements included the following:

- For the second consecutive year, NASA was voted the Best Place to Work in the Federal Government for large agencies, according to the Partnership for Public Service.
- The results of NASA's 2014 Diversity and Inclusion Survey show that NASA employees, by an overwhelming margin, believe that NASA promotes fair treatment of employees, regardless of their different diversity characteristics, and understand that having employees with diverse backgrounds is a business advantage for NASA.
- In FY 2014, NASA continued its focus on sustainability. NASA's inventory of sustainable facilities now exceeds 2.3 million square feet. NASA surpassed one of the primary energy conservation and green energy metrics of the Energy Independence and Security Act of 2007, and was very close to meeting another. NASA increased its use of renewable energy Agency-wide by 7.6 percent, and was within 0.6 percent of meeting the energy intensity goal reduction of 27 percent.
- NASA exceeded OMB's Sustainability Goals for Fleet Management.
- The Environmental Impact Statement (EIS) for the Cleanup and Demolition of Santa Susana Field Laboratory was finalized.
- NASA continues to make progress in the reduction of transaction costs and the management of high risk contract actions. The number of new Cost Plus Award Fee Contracts, delivery/task order, and non-competed actions are all down measurably from the same period in FY 2013.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

This strategic objective was rated as a focus area for improvement, but NASA will continue to make strides in effectively managing its people and continue the Agency's effort to renew and sustain its capabilities into fewer, more efficient facilities.

The Agency is taking the following steps:

- Investing in projects that reduce energy costs, demolishing unneeded infrastructure, and renewing and consolidating to reduce future operational costs and maintenance requirements.
- Exploring options to reduce operating costs.

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

Next Steps in FY 2015

- Continued use of targeted outreach and recruitment efforts to attract and advance a highly skilled and diverse workforce.
- Emphasis on work–life balance and continuous education and awareness opportunities on diversity and inclusion principles. Provide programs designed to create a more flexible, responsive work environment, such as the voluntary leave bank and increased telework opportunities.
- Explore standardized services, consolidated work weeks, and other innovative approaches to providing the business and administrative capabilities required to effectively support the mission.

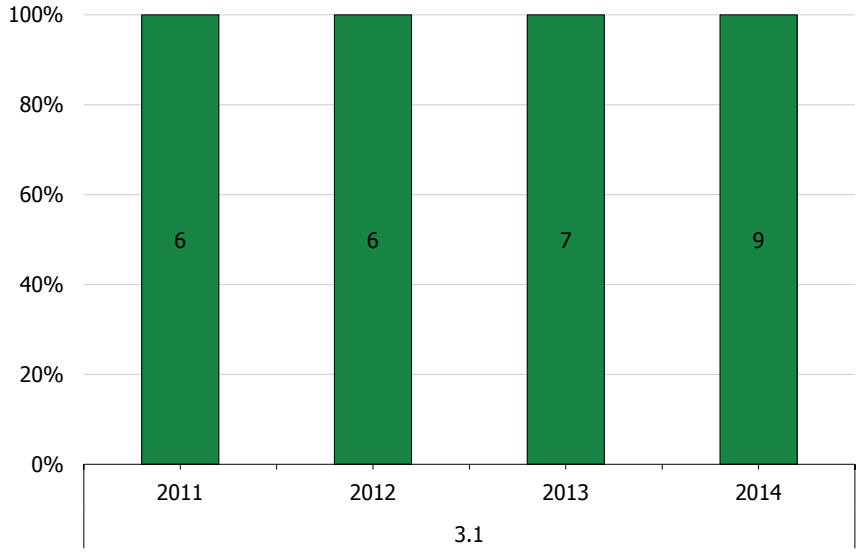
- Continue to explore opportunities for better alignment of the NASA workforce with current and future mission needs. This includes leveraging employee development and training initiatives to address workforce needs.
- Continue the Agency's efforts to renew and sustain its capabilities into fewer, more efficient facilities. Invest in energy saving initiatives and facilities maintenance to reduce risk and future liabilities and provide for more sustainable and cost efficient operations.
- Continue Environmental Compliance and Restoration cleanup activities of current or former sites where NASA operations contributed to environmental problems. Projects are ranked according to the relative urgency and the potential hazards related to each individual cleanup.

As part of the Technical Capabilities Assessment Team (TCAT) process, NASA is developing a method to strategically address the technical capabilities required to support Agency goals. This disciplined method will enable NASA to make informed decisions on investing and divesting strategically within the budget, while strengthening innovation in critical areas needed to advance the mission.

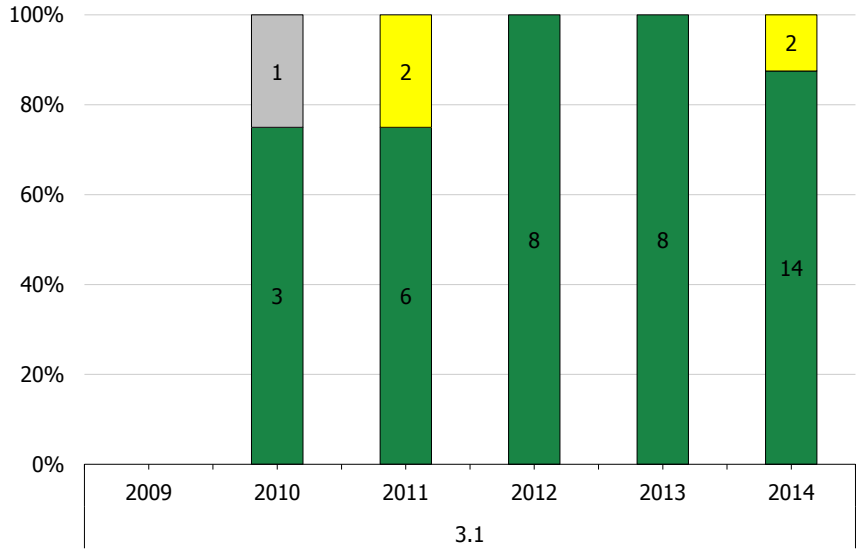
FY 2014 Performance Measures

Strategic Objective 3.1: Attract and advance a highly skilled, competent, and diverse workforce, cultivate an innovative work environment, and provide the facilities, tools, and services needed to conduct NASA's missions.								
Performance Goal 3.1.1: Define and build diverse workforce skills and competencies needed for the Agency's technology development and deep space exploration.	Performance Goal 3.1.2: Advance a workplace environment that affords equal employment opportunities (EEO) to all employees and takes proactive diversity and inclusion (D&I) efforts.	Performance Goal 3.1.3: Promote equal opportunity compliance and encourage best practices among NASA grant recipient institutions.	Performance Goal 3.1.4: Between 2012 and 2016, support the demolition and elimination of obsolete and unneeded facilities.	Performance Goal 3.1.5: Manage coordination of NASA's international and interagency activities in conjunction with the NASA mission directorates.	Performance Goal 3.1.6: Achieve savings for the Agency through acquisition reforms.	Performance Goal 3.1.7: Ensure that NASA continues progress towards implementing statutory or Executive Order targets and goals reflected in its annual Sustainability Plan.	Performance Goal 3.1.8: Enhance reach and effectiveness of programs and projects that engage the public.	Performance Goal 3.1.9: Manage coordination of advisory committees' (NASA Advisory Council and Aerospace Safety Advisory Panel) recommendations to the NASA Administrator.
Annual Performance Indicators								
• AMO-14-1: Sustain FY 2013 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.	• AMO-14-2: Assess, evaluate, and report the success of the NASA Model EEO Agency Plans FY 2008 to FY 2013. • AMO-14-3: Evaluate overall progress and effectiveness of the Agency Diversity and Inclusion Strategic Implementation Plan to date, in preparation for its completion in FY 2015.	• AMO-14-10: Broaden the scope of civil rights technical assistance to NASA grantees through the MissionSTEM Website on grantee civil rights requirements and promising practices for grantee compliance and diversity and inclusion. • AMO-14-11: Provide a civil rights compliance assessment at a minimum of two STEM or STEM-related programs that receive NASA funding.	• COF-14-1: Initiate the demolition or disposal of five facilities or structures during 2014 to reduce the Agency's footprint.	• AMO-14-26: Revise the NASA export control training module to update and strengthen the content to reflect changes in regulations and to respond to audit findings. • AMO-14-9: Negotiate and conclude international and interagency agreements with foreign and domestic partners in support of NASA missions.	• AMO-14-30: Achieve savings through increased use of both Federal-level and Agency-level strategic sourcing vehicles. • AMO-14-8: Achieve savings through increased contract efficiencies and reduced transaction costs in NASA procurements.	• AMO-14-20: Reduce energy intensity (energy consumption per gross square feet, or Btu/gsf) by 27 percent from 2003 baseline under 42 U.S.C. 8253. • AMO-14-21: Attain 14 percent sustainable building inventory by 2014. • AMO-14-22: Ensure that at least 7.5 percent of electricity is generated from renewable energy sources.	• AMO-14-13: Use current and emerging communications technologies to reach increasingly broad audiences. • AMO-14-28: Assess the use of NASA content by completing the portfolio of communications activities being built through the Communications Coordinating Council governance process.	• AMO-14-27: Provide NASA responses to advisory committees' recommendations made formally to the NASA Administrator.

Performance Goal Ratings for Strategic Objective 3.1, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 3.1, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Define and build diverse workforce skills and competencies needed for the Agency's technology development and deep space exploration.	5.1.1.1 Green	5.1.1.1 Green	5.1.1.1 Green	3.1.1 Green
Planned Future Performance				
For FY 2015 and FY 2016: Define and build diverse workforce skills and competencies needed for the Agency's mission.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management			

FY 2014 Performance Results

NASA is working 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.

- Recognizing and rewarding performance: NASA developed the annual NASA Innovation Awards to recognize, encourage, and celebrate a spirit of innovative behavior. There are two categories of awards, the Lean Forward; Fail Smart Award and the Champion of Innovation Award, and the NASA workforce selects the winner in each category.
- Engaging and connecting: NASA is working to create 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 has made great improvements in effective virtual collaboration. The Agency is able to conduct acquisition activities, panel interviews, international presentations, and entire conferences in virtual space.
- Growing 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 programs have a heavy emphasis on personal effectiveness, relating to others, and self-reflection. Approximately 500 NASA employees have gone through these two leadership development programs.

NASA demonstrated its commitment to workforce innovation by increasing its Innovation Index score from 77.2 percent in FY 2013 to 78.0 percent in FY 2014, as determined through three innovation-related questions in the annual Federal Employee Viewpoint Survey. Through the survey, NASA's employees expressed their opinions about their workplace environment and opportunities. The Innovation Index score is derived from the results on the following three questions:

- I feel encouraged to come up with new and better ways of doing things;
- I am constantly looking for ways to do my job better; and
- Creativity and innovation are rewarded.

Visit http://nasapeople.nasa.gov/ for more information.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Sustain FY 2013 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.	No API this fiscal year	10WF06 White	AMO-11-1 Yellow	AMO-12-1 Green	AMO-13-1 Green	AMO-14-1 Green
Planned Future Performance						
For FY 2015: AMO-15-1: 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.						
For FY 2016: AMO-16-1: 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.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Advance a workplace environment that affords equal employment opportunities (EEO) to all employees and takes proactive diversity and inclusion (D&I) efforts.	5.1.1.5 Green	5.1.1.5 Green	5.1.1.5 Green	3.1.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management			

FY 2014 Performance Results

NASA continued advancing equal employment opportunity (EEO) and diversity and inclusion (D&I) through its Model EEO Agency Plan and its D&I Plan, respectively. These plans lay out specific strategies and actions to increase racial, ethnic, gender, and other forms of diversity in the NASA workforce, proactively prevent discrimination and harassment, effectively manage the Agency's EEO complaints process, and enhance the inclusiveness of the Agency's work environments.

Over the past five years, NASA increased the percentages of individuals with disabilities, women, and racial and ethnic minorities in its workforce. Specifically, between 2008 and 2013, NASA increased the percentage of individuals with disabilities in its workforce by 11.8 percent for the overall population, and by 15.5 percent for targeted disabilities. NASA also increased the percentage of women, African-Americans, Asian American and Pacific Islanders, and Hispanics in senior-level General Schedule (GS) positions (i.e., GS-14 and GS-15 positions) and in the Senior Executive Service (SES). NASA increased the percentage of women in senior-level positions by 13.0 percent, African Americans by 20.6 percent, Asian American and Pacific Islanders by 10.9 percent, and Hispanics by 16.5 percent. Increases in these numbers over a five-year period suggest that the actions identified in the Model EEO Agency Plan to address potential barriers to EEO for individuals with disabilities, women, and minorities are having the intended outcome.

NASA also is continuing its efforts to proactively prevent discrimination and resolve issues and concerns promptly and efficiently by fully implementing EEO programs and processes, such as Alternative Dispute Resolution (ADR) in the EEO complaints process, the Conflict Management Program, reasonable accommodations for individuals with disabilities, and the Anti-Harassment Program. NASA is seeing successes, such as a continued downward trend over time in the filing of formal EEO complaints, particularly those alleging harassment, which points to the effectiveness of the Anti-Harassment Program. In

addition, NASA is developing a new set of reasonable accommodation procedures designed to enhance existing policy and to fully implement new laws in this arena, and evaluating the need for an Agency-wide centralized fund for reasonable accommodations. NASA also is actively engaged in a host of innovative initiatives, including a groundbreaking new framework for model EEO efforts, employee engagement, Special Emphasis Program utilization, and promising practices cross-pollination.

Despite these indicators of progress, NASA still is experiencing some challenges in EEO program service delivery. For example, there has not been an increase in how often ADR is used, and there has been an increase in the average number of processing days for addressing allegations under the Anti-Harassment Program. Nonetheless, NASA continues to work diligently to provide high-quality EEO programs to its workforce.

In addition to the numerous programs and initiatives mentioned above, NASA continues to regularly evaluate all programs and processes, and to look for ways to enhance program delivery. For example, NASA is launching a new Agency-wide push on ADR and other forms of conflict resolution promotion.

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

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Assess, evaluate, and report the success of the NASA Model EEO Agency Plans FY 2008 to FY 2013.	No API this fiscal year	10WF01 Green	AMO-11-7 Yellow	AMO-12-7 Green	AMO-13-2 Green	AMO-14-2 Green
Planned Future Performance						
For FY 2015: AMO-15-2: Sustain three programs and processes designed to proactively prevent discrimination, as outlined in the Model EEO Agency Plan.						
For FY 2016: AMO-16-2: Sustain three programs and processes designed to proactively prevent discrimination, as outlined in the Model EEO Agency Plan.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Evaluate overall progress and effectiveness of the Agency Diversity and Inclusion Strategic Implementation Plan to date, in preparation for its completion in FY 2015.	No API this fiscal year	10WF02 Green	AMO-11-8 Green	AMO-12-8 Green	AMO-13-3 Green	AMO-14-3 Green
Planned Future Performance						
For FY 2015: AMO-15-3: Assess, evaluate, and report the overall progress and effectiveness of the NASA Diversity and Inclusion Strategic Implementation Plan FY 2012 to FY 2015.						
For FY 2016: AMO-16-3: Issue and begin implementation of the NASA Diversity and Inclusion Strategic Implementation Plan FY 2016 to FY 2019.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Promote equal opportunity compliance and encourage best practices among NASA grant recipient institutions.	6.1.3.1 Green	6.1.3.1 Green	6.1.3.1 Green	3.1.3 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management			

FY 2014 Performance Results

NASA promotes equal opportunity compliance and encourages best practices among its grant recipient institutions through the Agency's onsite civil rights compliance reviews, compliance reports with specific recommendations for strengthening existing compliance and addressing specific compliance issues, and dissemination of promising practices of the institutions reviewed. Uniquely among grant-awarding federal science agencies, NASA conducts a proactive onsite compliance review program of all of the grant-related federal civil rights laws for which it has implementing regulations. This enables NASA to advance equal opportunity among its grantees regardless of race, color, national origin (including limited English proficiency), gender, age, or disability in the formal and informal science, technology, engineering, and mathematics (STEM) fields that are funded by NASA. During FY 2014, NASA conducted or is conducting civil rights compliance reviews on four grant recipient institutions.

NASA complements its compliance review programs with civil rights technical assistance that optimizes its online capabilities, while also utilizing more traditional media. The MissionSTEM Web site, launched in November 2012, is the centerpiece of NASA's civil rights technical assistance. MissionSTEM allows NASA to reach more of the grantee population, including administrators, faculty, and students in NASA-funded STEM programs. MissionSTEM is designed to highlight both compliance requirements under the civil rights laws, as well as the many promising practices of NASA's grant recipients and stakeholder organizations for creating greater diversity and inclusion in STEM. NASA continues to post fresh content, both written and video, to MissionSTEM on a regular basis, and continues to see increases in MissionSTEM usage over time. For example, between January and September 2014, MissionSTEM had over 69 thousand page views. By comparison, for the same period in 2013, MissionSTEM had 36 thousand page views, so the site saw a 90 percent increase in page views.

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

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Broaden the scope of civil rights technical assistance to NASA grantees through the MissionSTEM Website on grantee civil rights requirements and promising practices for grantee compliance and diversity and inclusion.	No API this fiscal year	10WF11 Green	AMO-11-19 Green	AMO-12-19 Green	AMO-13-11 Green	AMO-14-10 Green
Planned Future Performance						
For FY 2015: AMO-15-4: Continue to 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.						
For FY 2016: AMO-16-4: 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.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Provide a civil rights compliance assessment at a minimum of two STEM or STEM-related programs that receive NASA funding.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-11 Green
Planned Future Performance						
For FY 2015: AMO-15-5: Provide a civil rights compliance assessment at a minimum of two STEM or STEM-related programs that receive NASA funding.						
For FY 2016: No API this fiscal year						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Between 2012 and 2016, support the demolition and elimination of obsolete and unneeded facilities.	5.2.3.1 Green	5.2.3.1 Green	5.2.3.1 Green	3.1.4 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Construction of Facilities	**Contributing Program:** Institutional CoF			

FY 2014 Performance Results

NASA has a demolition program to eliminate obsolete, unneeded infrastructure to improve efficiency and eliminate safety and environmental risks. The program has been in operation for over a decade, and has been an important part of NASA's plans to reduce its infrastructure and operating costs.

NASA identifies facilities for demolition through special studies, which determine if the facility is required for current or future missions. Facilities that no longer are 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.

In FY 2014, NASA budgeted $16.7 million for demolition. Demolition activities have begun at Glenn Research Center, Johnson Space Center, Kennedy Space Center, Marshall Space Flight Center, and Stennis Space Center to demolish various facilities and structures.

More information is available at NASA's Office of Strategic Infrastructure Web site.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Initiate the demolition or disposal of five facilities or structures during 2014 to reduce the Agency's footprint.	No API this fiscal year	No API this fiscal year	COF-11-1 Green	COF-12-1 Green	COF-13-1 Green	COF-14-1 Green
Planned Future Performance						
For FY 2015: COF-15-1: Initiate the demolition or disposal of five facilities or structures during 2015 to reduce the Agency's footprint.						
For FY 2016: COF-16-1: Initiate the demolition or disposal of five facilities or structures during 2016 to reduce the Agency's footprint.						
Contributing Theme: Construction of Facilities	**Contributing Program:** Institutional CoF					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Manage coordination of NASA's international and interagency activities in conjunction with the NASA mission directorates.	5.5.2.1 Green	5.5.2.1 Green	5.5.2.1 Green	3.1.5 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management			

FY 2014 Performance Results

The Office of International and Interagency Relations (OIIR) manages the development of new and ongoing international and interagency activities, maintaining a continuous dialogue with key NASA officials and NASA's international and interagency partners on their requirements.

During FY 2014, OIIR produced monthly reports of international and interagency agreements on the management of 697 active international agreements with 122 countries. OIIR also concluded 83 new agreements with 48 countries and international organizations, and has more than 100 agreements in development.

OIIR's Export Control and Interagency Liaison Division conducted a series of training sessions for Center Export Administrators Agency-wide on the new regulations resulting from the President's Export Control Reform Initiative. The trainings included presentations by the Departments of Commerce, State, and Defense. The new regulations also were a key theme for the OIIR-sponsored Export Control Annual Program Review, which contained briefings and panel discussions led by the Assistant Secretary of Commerce for Export Administration, the driving force behind these reforms. In addition, the Headquarters Export Administrator provided briefings on the new regulations during All-Hands Sessions at Goddard Space Flight Center, Ames Research Center, and Kennedy Space Center, and the new regulations were featured during a day-long export control seminar offered at Johnson Space Center.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Revise the NASA export control training module to update and strengthen the content to reflect changes in regulations and to respond to audit findings.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-26 Green
Planned Future Performance						
For FY 2015: AMO-15-6: Revise the NASA export control training program plan to update and strengthen the content to reflect changes in regulations and to respond to audit findings.						
For FY 2016: AMO-16-6: Implement the Agency-wide export control training program plan.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Negotiate and conclude international and interagency agreements with foreign and domestic partners in support of NASA missions.	No API this fiscal year	No API this fiscal year	AMO-11-18 Green	AMO-12-18 Green	AMO-13-10 Green	AMO-14-9 Green
Planned Future Performance						
For FY 2015: AMO-15-7: Negotiate and conclude international and interagency agreements with foreign and domestic partners in support of NASA missions.						
For FY 2016: AMO-16-7: Negotiate and conclude international and interagency agreements with foreign and domestic partners in support of NASA missions.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Achieve savings for the Agency through acquisition reforms.	No PG this fiscal year	No PG this fiscal year	5.2.4.1 Green	3.1.6 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management			

FY 2014 Performance Results

NASA's Office of Procurement is on track to achieve this performance goal due to the successes achieved through strategic sourcing and to the plans made to expand strategic sourcing and reduce transaction costs. The Office of Procurement has made significant progress to achieve the majority of its planned initiatives. No significant threats have been identified that could jeopardize the success of these initiatives.

NASA's procurement efforts support the cross-agency priority goal on Strategic Sourcing, which is focused on reducing the costs of acquiring common products and services. During FY 2014, NASA made significant progress on a number of strategic sourcing vehicles, including the following:

- The Enterprise License Management Team (ELMT) manages Agency enterprise licenses and maintenance agreements; negotiating economy-of-scale pricing for selected software used by the Agency. The ELMT added 18 consolidated software license agreements to 24 existing agreements in FY 2014 that achieved a total estimated cost avoidance of $15 million.
- Web Enterprise Solutions and Technology (WEST) is consolidating Web services for NASA's diverse Web community, standardizing current systems and applying industry best practices, and improving agility in using tools and implementing services. WEST decommissioned 44 applications that were no longer relevant, resulting in a reduction to operations and maintenance costs from prior years of over 25 percent, or approximately $2.5 million.
- Solutions for Enterprise-Wide Procurement (SEWP) IV is a multi-award, government-wide acquisition contract vehicle focused on IT products and product-based services. For NASA, SEWP IV achieved cost savings of approximately $13 million for online competition and product refreshment, and avoided roughly $300 thousand in surcharge fees.

- The Synergy Achieving Consolidated Operations and Maintenance (SACOM) contract is merging operations and maintenance activities at the Stennis Space Center and Michoud Assembly Facility. The SACOM contract is targeted for award in FY 2015 and projected to result in a measurable reduction in costs for the Agency. NASA will begin reporting savings in FY 2015.
- The NASA Shared Services Center (NSSC) consolidates and standardizes select business activities from across NASA. NSSC performs select business activities for all NASA Centers in financial management, human resources, information technology, procurement, and business support services.

The Office of Procurement has made some progress on its planned initiatives to increase contract efficiencies, including the strategic procurement of information technology initiatives, reverse auctioning, reducing high-risk contract actions, and reducing procurement lead times. However, NASA would like to see continued progress in this area in the upcoming years. For example, the Office of Procurement has an effort underway to identify the causes for delays in awarding competitive contracts and recommend solutions for mitigating the delays. The initial focus of this effort is on source evaluation board procurements.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Achieve savings through increased use of both Federal-level and Agency-level strategic sourcing vehicles.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-30 Green
Planned Future Performance						
For FY 2015: AMO-15-8: Achieve savings through effective use of both Federal-level and Agency-level strategic sourcing approaches.						
For FY 2016: AMO-16-8: Achieve savings through effective use of both Federal-level and Agency-level strategic sourcing approaches.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Achieve savings through increased contract efficiencies and reduced transaction costs in NASA procurements.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-8 Yellow
Planned Future Performance						
For FY 2015: AMO-15-9: Achieve savings through increased contract efficiencies and reduced transaction costs in NASA procurements.						
For FY 2016: AMO-16-9: Achieve savings through increased contract efficiencies and reduced transaction costs in NASA procurements.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Explanation of Rating

The Office of Procurement made some progress on its planned initiatives in FY 2014 to increase contract efficiencies—strategic procurement of IT initiatives, reverse auctioning, reducing high-risk contract actions, peer review savings, reducing procurement lead times—but felt it fell short of intended targets. As a result, NASA rated AMO-14-8 yellow, with only minor threats identified that may impact progress on these initiatives moving forward. This shortfall did not affect NASA's overall progress towards achieving Performance Goal 3.1.6.

The Office of Procurement plans continued progress towards its initiatives in upcoming years. For example, it has an effort underway to identify the causes of delays in awarding competitive contracts and to recommend solutions for mitigating the delays. In FY 2015, NASA will focus its efforts on source evaluation board procurements and other initiatives, with the goal of improving the efficiency and timeliness of its performance.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Ensure that NASA continues progress towards implementing statutory or Executive Order targets and goals reflected in its annual Sustainability Plan.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	3.1.7 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management			

FY 2014 Performance Results

NASA has a sustainability policy to execute its mission without compromising the planet's resources. Sustainability provides a unique opportunity to continuously improve the resilience of NASA's space and ground asset operations and performance. Sustainability also involves taking action now to provide a future where the environment and living conditions are protected. In implementing sustainability practices, NASA manages risks to its mission, risks to the environment, and risks to 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. More information is available in the Strategic Sustainability Performance Plan.

The Office of Management and Budget released the January 2014 Scorecard on Sustainability/Energy in July 2014. NASA remains a leader in the Federal Government in progress made toward meeting the goals outlined, and received green ratings in six out of seven metrics.

Following were some of NASA's key sustainability activities in FY 2014:

- NASA fell slightly short of its target to reduce its energy consumption per gross square feet (Btu/GSF) by 27 percent in FY 2014, but is on track to meet its overall target of a 30 percent Btu/GSF reduction by FY 2015.
- NASA increased its inventory of sustainable buildings to 14.27 percent to date, measured by gross square footage, and is on track to meet the 15 percent goal by the end of FY 2015. For example, four buildings, with a combined size of 186,000 square feet, received Leadership in Energy and Environmental Design (LEED) gold certification. LEED is a green building certification program that recognizes best-in-class building strategies and practices.
- NASA generated 7.6 percent of its electricity from renewable energy sources, exceeding the target of 7.5 percent. NASA continues to make significant strides in generating electricity from renewable energy sources. For example, NASA has large renewable energy projects underway at three facilities, including one wind project and two solar projects.

NASA's sustainability efforts also support the cross-agency priority goal on Climate Change.

More information is available at NASA's Office of Strategic Infrastructure Web site.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Reduce energy intensity (energy consumption per gross square feet, or Btu/gsf) by 27 percent from 2003 baseline under 42 U.S.C. 8253.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-20 Yellow
Planned Future Performance						
For FY 2015: AMO-15-10: Reduce energy intensity (energy consumption per gross square feet, or Btu/gsf) by 30 percent from 2003 baseline under 42 U.S.C. 8253.						
For FY 2016: AMO-16-10: Reduce energy intensity (energy consumption per gross square feet, or Btu/gsf) by 32 percent from 2003 baseline under 42 U.S.C. 8253.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Explanation of Rating

NASA did not meet the FY 2014 goal of 27 percent, which resulted in a yellow rating for AMO-14-20. Title 42 of U.S. Code 8253 sets energy conservation targets for buildings within the Federal Government. This performance shortfall did not affect progress towards achieving Performance Goal 3.1.7.

NASA is on track to meet the 30 percent target by FY 2015. The Office of Strategic Infrastructure anticipates awarding several Energy Savings Performance Contracts (ESPCs), ensuring continued progress toward the 30 percent goal. ESPCs are contracts that promote energy and water conservation through technologies, services, and operations.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Attain 14 percent sustainable building inventory by 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-21 Green
Planned Future Performance						
For FY 2015: AMO-15-11: Attain 15 percent sustainable building inventory by 2015.						
For FY 2016: AMO-16-11: 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 2016 in the Energy and Sustainability Scorecard.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Ensure that at least 7.5 percent of electricity is generated from renewable energy sources.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-22 Green
Planned Future Performance						
For FY 2015: AMO-15-12: Ensure that at least 10 percent of electricity consumed is generated from renewable energy sources.						
For FY 2016: AMO-16-12: Ensure that at least 15 percent of electricity consumed is generated from renewable energy sources.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Enhance reach and effectiveness of programs and projects that engage the public.	6.4.2.1 Green	6.4.2.1 Green	6.4.2.1 Green	3.1.8 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management			

FY 2014 Performance Results

NASA's Office of Communications implemented a series of communication campaigns, approved by NASA's Communications Coordinating Council, in FY 2014. These campaigns integrate traditional and social media and public outreach activities from across the Agency's mission directorates, programs, projects, and Headquarters and Center functional communications offices. Regular updates on campaign progress and results are briefed at Communications Coordinating Council meetings. During the fourth quarter of FY 2014, the Office of Communications held an all-hands video teleconference that provided over 400 Agency employees a status of the communication priorities and campaigns.

NASA's public Web site customer satisfaction scores are among the highest in the Federal Government. The NASA Web portal (www.nasa.gov) averaged 6.6 million visits per month during the fourth quarter of FY 2014. This is up from just under 5 million per month in the previous quarter. The Agency continues to assess new social media tools and techniques to engage both science attentive and non-traditional audiences. NASA has recently launched Vine from the International Space Station (ISS), where Astronaut Reid Wiseman has been sharing six-second videos of life aboard the ISS. The audience has grown to nearly 110,000 in the few months since the site began operating. The audience on the image-sharing site Instagram continues to grow, now at 1.7 million followers, up from 1.3 million the previous quarter. NASA's Facebook audience has grown to 7.6 million and has surpassed Twitter's audience of 7.5 million, to be its largest social media audience. NASA continues to lead the Federal Government in followers on Facebook, Google+, Foursquare, Twitter, and Instagram. The Headquarters Office of Communications process for approving new social media accounts continues to be a useful mechanism to ensure both the quality and cost effectiveness of the Agency's investments in this area.

The Office of Communication has continued implementation of the Communications Portfolio review process in order to evaluate new and ongoing Agency communications activities. Communications events, activities, and products are evaluated based on best practices, audience reach, and resource requirements. The Office of Communications has developed a distributed Communications Portfolio online database, with plans to implement the system across the Agency in FY 2015. The database will improve and help standardize data collection and reporting of communications activities, events, and products, leading to more effective stakeholder engagement.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Use current and emerging communications technologies to reach increasingly broad audiences.	No API this fiscal year	No API this fiscal year	AMO-11-21 Green	AMO-12-21 Green	AMO-13-13 Green	AMO-14-13 Green
Planned Future Performance						
For FY 2015: AMO-15-13: Use current and emerging communications technologies, platforms, and methods to reach increasingly broad and diverse audiences.						
For FY 2016: AMO-16-13: Use current and emerging communications technologies, platforms, and methods to reach increasingly broad and diverse audiences.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Assess the use of NASA content by completing the portfolio of communications activities being built through the Communications Coordinating Council governance process.	No API this fiscal year	No API this fiscal year	AMO-11-22 Green	AMO-12-22 Green	AMO-13-14 Green	AMO-14-28 Green
Planned Future Performance						
For FY 2015: AMO-15-14: Develop a set of metrics by which to assess the reach and effectiveness of activities in the communications portfolio.						
For FY 2016: AMO-16-14: Develop a set of metrics by which to assess the reach and effectiveness of activities in the communications portfolio.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: AMO-16-24: Develop 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.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Manage coordination of advisory committees' (NASA Advisory Council and Aerospace Safety Advisory Panel) recommendations to the NASA Administrator.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	3.1.9 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.'				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management			

FY 2014 Performance Results

In addition to its work with international and interagency partners, the Office of International and Interagency Relations (OIIR) supports NASA's advisory committees, including the NASA Advisory Council (NAC) and the Aerospace Safety Advisory Panel (ASAP). During FY 2014, OIIR coordinated NASA's response to 16 NAC and 9 ASAP recommendations. It also led Agency-wide management oversight and legal compliance for NASA's six Federal Advisory Committee Act (FACA) committees; planned and executed internal Agency and public rollout of the NAC reorganization; organized and implemented 14 NASA federal advisory committee meetings, including three Council meetings, three ASAP meetings, and eight ASAP "Insight" meetings; and prepared the ASAP 2013 Annual Report to Congress.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Provide NASA responses to advisory committees' recommendations made formally to the NASA Administrator.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-27 Green
Planned Future Performance						
For FY 2015: AMO-15-15: Provide NASA responses to advisory committees' recommendations made formally to the NASA Administrator.						
For FY 2016: AMO-16-15: Provide NASA responses to advisory committees' recommendations made formally to the NASA Administrator.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency Management					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Does not trend to FY 2014.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	None
Planned Future Performance				
For FY 2015: No performance goal this fiscal year				
For FY 2016: 3.1.10: Between 2016 and 2017, demonstrate increased facility reliability by reducing spending on unscheduled maintenance from 35 percent to 31 percent of total maintenance spending.				
Contributing Theme: Construction of Facilities	**Contributing Program:** Institutional CoF			

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: COF-16-2: Reduce spending on unscheduled maintenance (out of total maintenance spending) by at least two percentage points.						
Contributing Theme: Construction of Facilities	**Contributing Program:** Institutional CoF					

Strategic Objective 3.2

Ensure the availability and continued advancement of strategic, technical, and programmatic capabilities to sustain NASA's Mission.

Lead Office
Human Exploration and Operations Mission Directorate (HEOMD)

Goal Leader
Greg Williams, Deputy for Policy and Management, HEOMD

Contributing Programs
21st Century Space Launch Complex (21CSLC), Launch Services Program (LSP), Rocket Propulsion Test (RPT), Programmatic Construction of Facilities, Space Communications and Navigation (SCaN), Strategic Capabilities Assets Program (SCAP)

Budget for Strategic Objective 3.2

	Actual	Enacted	Requested	Notional			
Budget Authority (in $ millions)	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$900	---	$853	$834	$781	$762	$743

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
NASA will maintain all critical network and communication capabilities; complete launch and range complex modernization projects; continue to promote the evolution of a U.S. commercial space launch market, as well as the continual enhancement of space transportation policy, contracts, and launch service products and services; ensure that the RPT capabilities and competencies are available; and ensure that the SCAP capabilities are available to support test customers.

Update of Progress Toward Strategic Objective
NASA, in consultation with the Office of Management and Budget, has highlighted this strategic objective as a focus area for improvement.

The NASA 2014 Strategic Review found that:

- NASA rated this strategic objective as a focus area for improvement primarily due to programmatic issues within the SCaN portfolio, specifically contractor performance on the Space Network Ground Segment Sustainment (SGSS) Project. SGSS is currently undergoing a replan.
- Strategies and performance are sufficient for most of the strategic objective's programs. However, strategies for ScaN required adjustment, due to:

  - Inability to find partner funding for the Tracking and Data Relay Satellite (TDRS)-M launch service.
  - Cost and schedule growth on the SGSS effort.
- These challenges constituted a significant FY 2014 challenge to the Agency's critical network and communication activities.

FY 2014 achievements included the following:

- The twelfth TDRS spacecraft (TDRS-L) was launched in January 2014, and has been accepted for operations.
- LSP achieved a 100 percent success rate in FY 2014 with the successful launch of three NASA missions.
- RPT performed 313 tests for 272,393 seconds, while maintaining 100 percent of availability.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

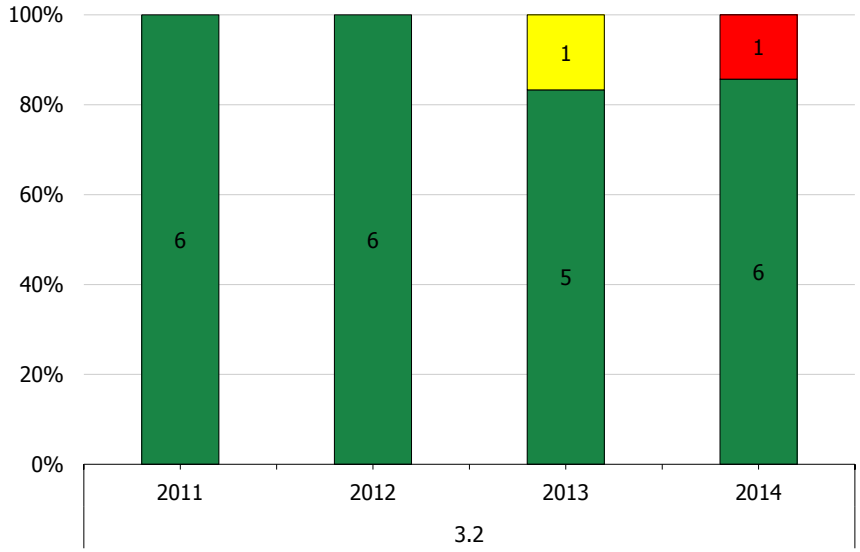
Next Steps in FY 2015

- Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success (SCaN).
- Continue the development of enabling technology and international standards (SCaN).
- Maintain civil space leadership in radio-frequency spectrum policy, planning, and management (SCaN).
- Complete environmental mitigation projects and the development of systems to support small-class vehicle customers at the Kennedy Space Center and begin range telemetry systems upgrades.

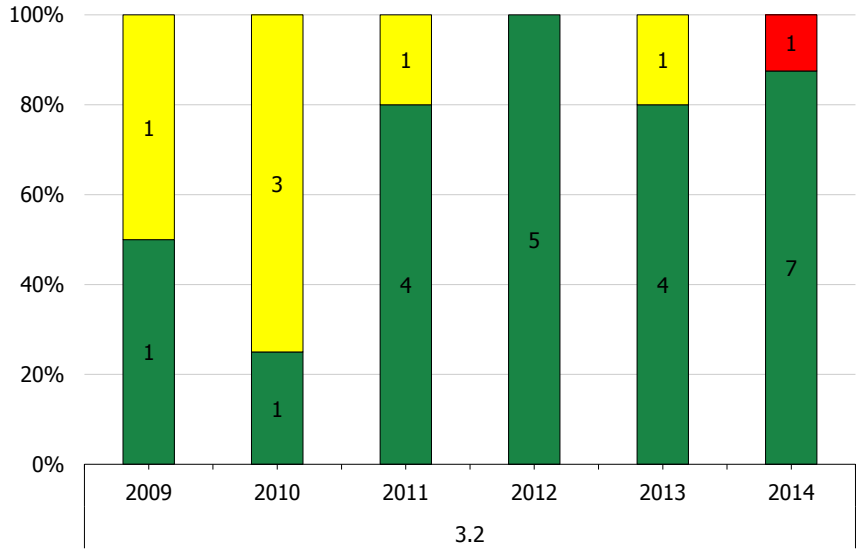
FY 2014 Performance Measures

Strategic Objective 3.2: Ensure the availability and continued advancement of strategic, technical, and programmatic capabilities to sustain NASA's Mission.						
Performance Goal 3.2.1: Review the current state of the NASA test capabilities, known test requirements and test requests, and revise the Master Plan as needed.	Performance Goal 3.2.2: Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.	Performance Goal 3.2.3: By 2014, launch two functionally identical Tracking and Data Relay Satellite (TDRS) spacecraft in geosynchronous orbits to replenish the Tracking and Data Relay Satellite System (TDRSS) constellation.	Performance Goal 3.2.4: By FY 2016, replace or upgrade obsolete and unsustainable systems of the Tracking and Data Relay Satellite System (TDRSS) Ground Segment at the White Sands Complex (WSC).	Performance Goal 3.2.5: By FY 2018, replace aging Deep Space Network (DSN) 70-meter antenna at Canberra Deep Space Communications Complex (CDSCC).	Performance Goal 3.2.6: Prioritize and complete launch and range complex modernization studies and projects to sustain government and commercial capabilities at the Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS).	Performance Goal 3.2.7: Ensure the strategic availability and maintenance of facilities that are necessary to meet the long-term needs and requirements of the Agency.
Annual Performance Indicators						
• SFS-14-1: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.	• SFS-14-2: 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. • SFS-14-3: Complete acquisitions on time for NASA-managed expendable launches.	• SFS-14-4: Complete in-orbit check-out of Tracking and Data Relay Satellite (TDRS)-L spacecraft.	• SFS-14-5: Make progress towards the Space Network Ground Segment Sustainment (SGSS) Systems Integration Review (SIR).	• SFS-14-6: Complete the radio frequency equipment installation at Canberra Deep Space Communications Complex (CDSCC) to support operations.	• SFS-14-7: Complete environmental mitigation projects to support horizontal take-off, horizontal landing commercial partner at the Shuttle Landing Facility (SLF); complete development of the Deployable Launch System and Universal Propellant Servicing System to enable a small-class vehicle launch capability at Kennedy Space Center; and begin range telemetry systems upgrades.	• SC-14-1: Achieve a minimum of 80 percent overall availability of Strategic Capabilities Assets Program (SCAP) portfolio of assets which are necessary to meet the long-term needs and requirements of the Agency.

Performance Goal Ratings for Strategic Objective 3.2, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 3.2, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Review the current state of the NASA test capabilities, known test requirements and test requests, and revise the Master Plan as needed.	5.3.1.1 Green	5.3.1.1 Green	5.3.1.1 Green	3.2.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Space and Flight Support	**Contributing Program:** Rocket Propulsion Test			

FY 2014 Performance Results

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. RPT prioritizes limited resources to sustain its core test capability and meet customer test requirements. In addition, 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 capability to better meet national test needs through intra- and inter-agency cooperation, and recommends solutions that provide the best overall value to taxpayers.

In FY 2014, the RPT program successfully met all customer test requirements. RPT facilities completed 313 tests for a total of 272,393 seconds of test time. During FY 2014, the RPT program completed the following tests:

- The J-2X rocket engine for NASA's Space Launch System (SLS). The J-2X was designed for the Ares upper stage under Constellation Program and is now a candidate for the SLS upper stage.
- The Rocket Stage (RS)-68 engine for the U.S. Air Force.
- Other tests for numerous commercial partners, including Orbital Sciences Corporation, Space Exploration Technologies Corporation (SpaceX), MDA Corporation, and the Boeing Company.

In addition, the SLS program is making major renovations to the B-2 test stand (an RPT-managed test stand) at Stennis Space Center in preparation for SLS core stage testing in FY 2016.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.	9SFS3 Yellow	10SFS09 Yellow	SFS-11-1 Green	SFS-12-1 Green	SFS-13-1 Green	SFS-14-1 Green
Planned Future Performance						
For FY 2015: SFS-15-2: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.						
For FY 2016: SFS-16-2: Sustain 90 percent availability of test facilities to support NASA and other customers' planned test requirements.						
Contributing Theme: Space and Flight Support	**Contributing Program:** Rocket Propulsion Test					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches.	5.4.1.1 Green	5.4.1.1 Green	5.4.1.1 Green	3.2.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Space and Flight Support	**Contributing Program:** Launch Services			

FY 2014 Performance Results

NASA's Launch Services Program (LSP) is responsible for the acquisition and management of expendable launch vehicle missions. LSP provides safe, reliable, cost-effective, and on-schedule launch services to NASA and NASA-sponsored payloads on expendable launch vehicle missions. LSP oversees all aspects of launch services, including launch vehicle engineering and manufacturing, launch operations and countdown management, and quality and mission assurance.

In FY 2014, LSP sustained a 100 percent success rate for mission launches. All three of the following missions were delivered to the proper orbit and met the launch mission requirements defined in the NASA Launch Services II contract:

- Mars Atmosphere and Volatile EvolutioN (MAVEN) mission, launched on November 18, 2013, will explore the upper atmosphere of Mars.
- Tracking Data and Relay Satellite (TDRS)-L, launched on January 23, 2014, will provide operational communications data.
- Orbiting Carbon Observatory (OCO)-2, launched on July 2, 2014, will study atmospheric carbon dioxide from space.

In addition, LSP completed acquisitions on time for all NASA-managed expendable launches. Specifically, LSP completed three acquisitions, totaling approximately $388 million, for the following missions:

- Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) will study the deep interior of Mars.
- Solar Orbiter will make in-situ observations of the heliosphere.
- Cyclone Global Navigation Satellite System (CYGNSS) will measure ocean surface winds to improve hurricane forecasting.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 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.	No API this fiscal year	10SFS11 Green	SFS-11-2 Yellow	SFS-12-2 Green	SFS-13-2 Green	SFS-14-2 Green
Planned Future Performance						
For FY 2015: SFS-15-3: 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.						
For FY 2016: SFS-16-3: 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.						
Contributing Theme: Space and Flight Support	**Contributing Program:** Launch Services					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete acquisitions on time for NASA-managed expendable launches.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	SFS-14-3 Green
Planned Future Performance						
For FY 2015: SFS-15-4: Complete acquisitions on time for NASA-managed expendable launches.						
For FY 2016: SFS-16-4: Complete acquisitions on time for NASA-managed expendable launches.						
Contributing Theme: Space and Flight Support	**Contributing Program:** Launch Services					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
By 2014, launch two functionally identical Tracking and Data Relay Satellite (TDRS) spacecraft in geosynchronous orbits to replenish the Tracking and Data Relay Satellite System (TDRSS) constellation.	5.4.3.1 Green	5.4.3.1 Green	5.4.3.1 Green	3.2.3 Green
Planned Future Performance				
For FY 2015 and FY 2016: 3.2.3: Maintain a minimum of 95 percent delivery of the Space Communications network services that support NASA and other customers' mission success.				
Contributing Theme: Space and Flight Support	**Contributing Program:** Space Communications and Navigation			

FY 2014 Performance Results

The NASA Space Communications and Navigation (SCaN) Program is responsible for Agency-wide operations, management, and development of all NASA space communications capabilities and enabling technology. SCaN manages and directs the ground-based facilities and services for three networks that span the globe and support over 100 space missions. The Space Network, which is one of the three networks, consists of a constellation of geosynchronous (Earth-orbiting) satellites named the Tracking Data Relay Satellite (TDRS), ground systems that operate as a relay system between satellites, satellites in low Earth orbit above 73 kilometers, and ground facilities. The Space Network maintains near-continuous communications with the International Space Station (ISS), the Hubble Space Telescope, and other satellites beyond low Earth orbit, and supports resupply missions to the ISS.

During FY 2014, SCaN completed this performance goal. NASA launched TDRS-K on January 30, 2013, and TDRS-L on January 23, 2014. The replenishment of the TDRS fleet will help to ensure that NASA's Space Network is able to continue to provide around-the-clock, high throughput communications services to NASA's missions, including the ISS.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete in-orbit check-out of Tracking and Data Relay Satellite (TDRS)-L spacecraft.	9SFS6 Green	10SFS07 Yellow	SFS-11-5 Green	SFS-12-5 Green	SFS-13-4 Green	SFS-14-4 Green
Planned Future Performance						
For FY 2015: SFS-15-5: Complete Tracking and Data Relay Satellite (TDRS)-L Initial Operational Capability (IOC).						
For FY 2016: SFS-16-5: Complete the development of the Tracking and Data Relay Satellite (TDRS)-M Spacecraft and prepare it for storage.						
Contributing Theme: Space and Flight Support	**Contributing Program:** Space Communications and Navigation					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
By FY 2016, replace or upgrade obsolete and unsustainable systems of the Tracking and Data Relay Satellite System (TDRSS) Ground Segment at the White Sands Complex (WSC).	5.4.3.2 Green	5.4.3.2 Green	5.4.3.2 Yellow	3.2.4 Red
Planned Future Performance				
For FY 2015 and FY 2016: 3.2.4: Replace or upgrade obsolete and unsustainable systems of the Tracking and Data Relay Satellite System (TDRSS) Ground Segment at the White Sands Complex (WSC).				
Contributing Theme: Space and Flight Support	**Contributing Program:** Space Communications and Navigation			

FY 2014 Performance Results

NASA's Space Communications and Navigation (SCaN) Program manages the Space Network, which maintains near-continuous communications with the International Space Station (ISS), the Hubble Space Telescope, and other satellites beyond low Earth orbit, and resupply missions to the ISS. The Space Network consists of a ground segment and a space segment. The ground segment comprises three facilities, including one located on Guam Island; and two located in New Mexico, one of which is the White Sands Test Facility.

The current ground system of equipment for the Space Network is approximately 30 years old and is becoming more difficult to operate and maintain. As newer systems replace older ones, it becomes increasingly difficult for the older systems to interface with the new ones and function at full capacity.

The SCaN initiated a sustainment effort, called the Space Network Ground Segment Sustainment (SGSS) Project, to upgrade technology and sustain the Space Network operations for at least the next 25 years. This includes replacing or upgrading the ground segment at the White Sands Test Facility.

During FY 2014, the SGSS Project made incremental progress, but exceeded the cost and schedule estimates in the Agency's baseline commitment.

Performance Improvement Plan

NASA is working to replan and rebaseline the project, with a revised expected completion date of FY 2018. NASA expects to complete the replan of the SGSS Project, which will include Agency approval of a revised Key Decision Point (KDP)-C memorandum, by June 2015. The KDP-C review is an assessment of a project's readiness to move into full-scale development.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Make progress towards the Space Network Ground Segment Sustainment (SGSS) Systems Integration Review (SIR).	No API this fiscal year	10SFS08 Yellow	SFS-11-6 Green	SFS-12-6 Green	SFS-13-5 Yellow	SFS-14-5 Red
Planned Future Performance						
For FY 2015: SFS-15-6: Complete the A4 Space Network Ground Segment Sustainment (SGSS) software increment delivery.						
For FY 2016: SFS-16-6: Complete the A5 Space Network Ground Segment Sustainment (SGSS) software increment delivery.						
Contributing Theme: Space and Flight Support	**Contributing Program:** Space Communications and Navigation					

Explanation of Rating

The SGSS Project did not complete this milestone in FY 2014 and does not anticipate completing it in FY 2015. As a result, NASA rated SFS-14-5 red. The SCaN program is working to replan the project. The timeframe for completing the SGSS replan, which will include Agency approval of a delta KDP-C, is summer 2015. The replan will include a revised schedule.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
By FY 2018, replace aging Deep Space Network (DSN) 70-meter antenna at Canberra Deep Space Communications Complex (CDSCC).	5.4.3.3 Green	5.4.3.3 Green	5.4.3.3 Green	3.2.5 Green
Planned Future Performance				
For FY 2015 and FY 2016: 3.2.5: Replace aging Deep Space Network (DSN) 70-meter antenna at Canberra Deep Space Communications Complex (CDSCC).				
Contributing Theme: Space and Flight Support	**Contributing Program:** Space Communications and Navigation			

FY 2014 Performance Results

NASA's Space Communications and Navigation (SCaN) Program manages the Deep Space Network, which is an international network of antennas that supports interplanetary spacecraft missions, space-based telescopes, and some select Earth-orbiting science missions. The Deep Space Network comprises three facilities, the Canberra Deep Space Communications Complex (CDSCC) in Australia; the Goldstone Deep Space Communications Complex in Fort Irwin, CA; and the Madrid Deep Space Communications Complex in Spain. The Deep Space Network supports NASA and non-NASA missions that explore the furthest points of the solar system, including Kepler, Cassini, the Mars Rovers and Orbiters, the Mars Science Laboratory, Voyager 1 and 2, and the Spitzer Space Telescope.

To meet ongoing demand for deep space communication services, SCaN is replacing its aging Deep Space Station (DSS) 70-meter antennas with a new generation of 34-meter antennas. Four 34-meter antennas will be arrayed in order to provide functionally equivalent capabilities to the 70-meter antenna at the CDSCC, which is over 40 years old. SCaN is on schedule to complete two new 34-meter antennas, which will be arrayed with the existing two 34-meter antennas to provide redundancy and eliminate the critical dependence on the old 70-meter antenna.

In September 2014, NASA completed installation of the DSS-35, which is a 34-meter beam waveguide antenna. It has the same basic performance parameters of the previous 34-meter High-Efficiency antenna, but the beam waveguide antenna design relocates sensitive electronics from the center of the main reflector to the pedestal equipment room, offering easier access for maintenance and modifications. The DSS-35 is now fully operational.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete the radio frequency equipment installation at Canberra Deep Space Communications Complex (CDSCC) to support operations.	No API this fiscal year	No API this fiscal year	SFS-11-7 Green	SFS-12-7 Green	SFS-13-6 Green	SFS-14-6 Green
Planned Future Performance						
For FY 2015: SFS-15-7: Complete the antenna structure at Canberra Deep Space Communications Complex (CDSCC) for Deep Space Station-36 (DSS-36).						
For FY 2016: SFS-16-7: Initiate installation of electronics at Canberra Deep Space Communications Complex (CDSCC) for Deep Space Station (DSS-36).						
Contributing Theme: Space and Flight Support	**Contributing Program:** Space Communications and Navigation					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Prioritize and complete launch and range complex modernization studies and projects to sustain government and commercial capabilities at the Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS).	5.4.2.1 Green	5.4.2.1 Green	5.4.2.1 Green	3.2.6 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Space and Flight Support	**Contributing Program:** 21st Century Space Launch Complex			

FY 2014 Performance Results

NASA created the 21st Century Space Launch Complex (21CSLC) program in FY 2011 to modernize Kennedy Space Center and Cape Canaveral Air Force Station. The goal of the enhanced complex is to facilitate multiple launches of different vehicle types from different companies carrying both humans and cargo to space in a cost-effective and timely manner. Other important projects include enhancements to the range, payload processing capabilities, and environmental clean-up activities.

In FY 2014, 21CSLC completed an environmental mitigation of the Shuttle Landing Facility and made an arrangement with Space Florida for its management. NASA's commercial partners for the Shuttle Landing Facility, including Morpheus and StarFighter, LLC, actively used the site, and Stratolaunch Systems was in the process of evaluating the site.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Complete environmental mitigation projects to support horizontal take-off, horizontal landing commercial partner at the Shuttle Landing Facility (SLF); complete development of the Deployable Launch System and Universal Propellant Servicing System to enable a small-class vehicle launch capability at Kennedy Space Center; and begin range telemetry systems upgrades.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	SFS-14-7 Green
Planned Future Performance						
For FY 2015: SFS-15-8: Complete extension of utilities to support the first horizontal take-off, horizontal landing commercial partner at the Shuttle Landing Facility (SLF), and complete upgrades to the range telemetry systems.						
For FY 2016: SFS-16-8: Complete activities and close out the 21st Century Space Launch Complex Program.						
Contributing Theme: Space and Flight Support	**Contributing Program:** 21st Century Space Launch Complex					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Ensure the strategic availability and maintenance of facilities that are necessary to meet the long-term needs and requirements of the Agency.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	3.2.7 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Strategic Capabilities Assets Program			

FY 2014 Performance Results

The NASA Strategic Capabilities Assets Program (SCAP) ensures that essential Agency test facilities are maintained in a state of readiness. SCAP 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 SCAP include thermal vacuum chambers, simulators, and the Arc Jet Facility.

For the period ending in FY 2014, SCAP achieved an overall availability of approximately 98 percent for its portfolio of assets.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Achieve a minimum of 80 percent overall availability of Strategic Capabilities Assets Program (SCAP) portfolio of assets which are necessary to meet the long-term needs and requirements of the Agency.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	SC-14-1 Green
Planned Future Performance						
For FY 2015: SC-15-1: Achieve a minimum of 80 percent overall availability of Strategic Capabilities Assets Program (SCAP) portfolio of assets which are necessary to meet the long-term needs and requirements of the Agency.						
For FY 2016: SC-16-1: Achieve a minimum of 80 percent overall availability of Strategic Capabilities Assets Program (SCAP) portfolio of assets which are necessary to meet the long-term needs and requirements of the Agency.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Strategic Capabilities Assets Program					

Strategic Objective 3.3

Provide secure, effective, and affordable information technologies and services that enable NASA's Mission.

Lead Office
Office of the Chief Information Officer (OCIO)

Goal Leader
Larry Sweet, CIO

Contributing Programs
Agency IT Services

Budget for Strategic Objective 3.3

Budget Authority (in $ millions)	Actual FY 2014	Enacted FY 2015	Requested FY 2016	Notional FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$162	---	$179	$182	$184	$187	$190

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
Information technology and process support the shift from legacy work patterns to a seamless collaborative and mobile work environment that safeguards NASA's information assets. Information technology (IT) resources are transparently aligned and prioritized via stakeholder engagement to optimize IT enablement of NASA's mission and vision. Funding and operational efficiencies are identified and executed to enable opportunities to reinvest in both the advancement of NASA's programs and IT capabilities.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- Appropriate strategies have been formulated and aligned to drive achievement of this strategic objective.
- The release of the 2014 NASA Information Resources Management (IRM) Strategic Plan and other documentation provide a refreshed IT foundation and direction for the next several years.
- Agency IT Services continue to meet and typically exceed key service level agreement performance measures while implementing cost-saving IT solutions. Most major planned activities are being implemented as expected.

- Milestones for three activities (Data Center Consolidation, Personal Identity Verification (PIV) Strong Authentication, and Trusted Internet Connection (TIC) 2.0), each a mandated cross-agency priority (CAP) goal, are at risk for on-schedule completion of FY 2014 goals. However, OCIO anticipates full completion of these CAP goals by FY 2015.
- Opportunities identified include the following:
    - Implementation of new and strengthened capabilities.
    - Implementation of Network Transformation.
    - Maturing "enterprise-first" approach and expanded IT governance.

FY 2014 achievements included the following:

- NASA migrated over 150 Web applications to the Cloud.
- Several enhancements were made to NASA cybersecurity.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan. In addition, the 2014 NASA Information Resource Management (IRM) Strategic Plan provides the IT foundation and direction for the next several years.

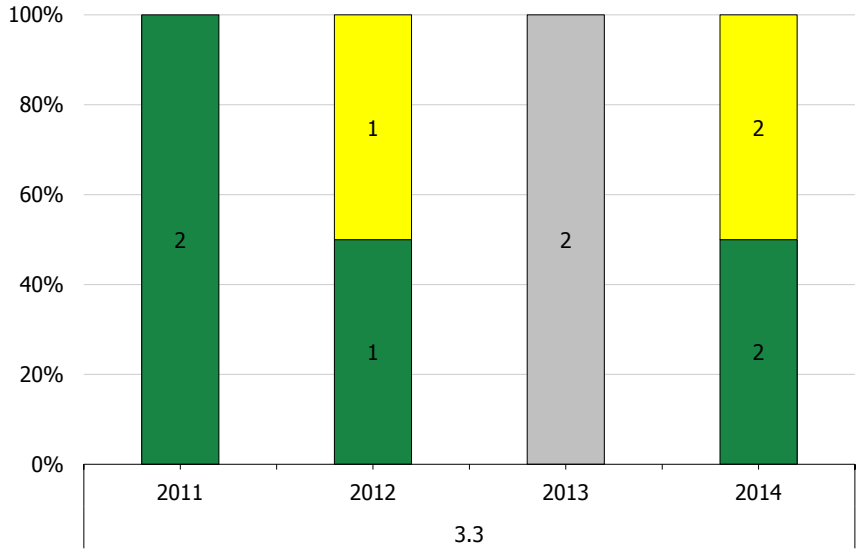
Next Steps in FY 2015

- Plan and implement security technology upgrades for the Security Operations Center (SOC).
- Maintain data center consolidation efforts.

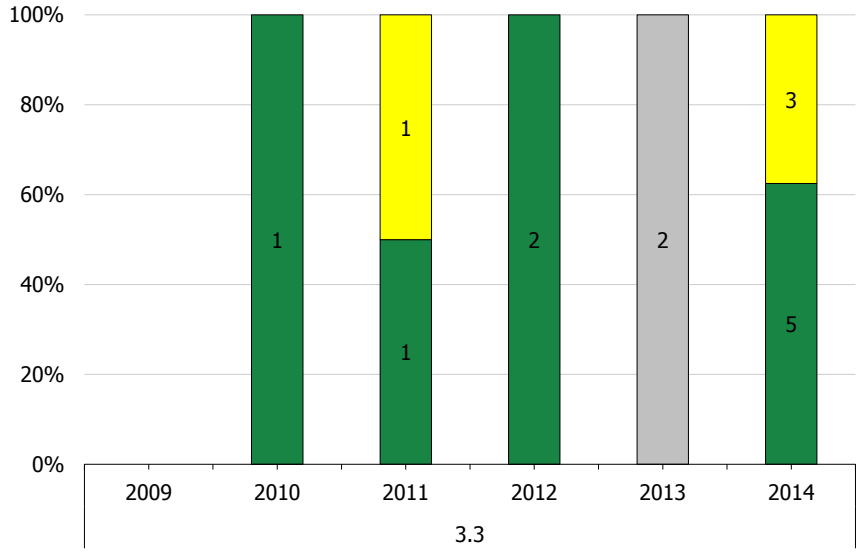
FY 2014 Performance Measures

Strategic Objective 3.3: Provide secure, effective, and affordable information technologies and services that enable NASA's Mission.			
Performance Goal 3.3.1: Enhance NASA's information security posture through implementation of automated security and privacy tools and technologies.	Performance Goal 3.3.2: Identify viable alternatives to support Federal and Agency mobility goals, supporting Work from Anywhere (WFA).	Performance Goal 3.3.3: Consolidate and centralize the management of information technology (IT) enterprise services for end user services, communications, and enterprise applications.	Performance Goal 3.3.4: By 2015, reduce the number of data centers to 22.
Annual Performance Indicators			
• AMO-14-17: Identify new tools and technologies needed to support automated security and privacy systems. • AMO-14-19: Achieve 95 percent implementation of continuous monitoring cybersecurity capabilities. • AMO-14-23: Achieve 50 percent implementation of strong authentication cybersecurity capabilities. • AMO-14-24: Achieve 99 percent implementation of Trusted Internet Connection consolidation cybersecurity capabilities. • AMO-14-25: Achieve 100 percent implementation of Trusted Internet Connection 2.0 cybersecurity capabilities.	• AMO-14-18: Implement a Mobile Device Management (MDM) capability to support access to NASA email and calendaring services from government and personally owned mobile devices.	• AMO-14-29: Transition 150 Web applications to the cloud.	• AMO-14-7: Maintain the FY 2014 schedule of five data center consolidations contained in NASA Federal Data Center Consolidation Plan.

Performance Goal Ratings for Strategic Objective 3.3, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 3.3, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Enhance NASA's information security posture through implementation of automated security and privacy tools and technologies.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	3.3.1 Yellow
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services			

FY 2014 Performance Results

NASA's Office of the Chief Information Officer (OCIO) made progress toward achieving this information security performance goal, with two mitigated exceptions that caused NASA to rate this performance goal yellow. Below are OCIO's achievements for FY 2014 and performance improvement plans for FY 2015.

Automated Security and Privacy Systems

OCIO completed a study to identify the IT security tools currently in use across NASA that are managed and funded at the enterprise level. Further analysis is being performed to validate the IT security areas and identify additional tool candidates for enterprise deployment to support automated security monitoring, detection, and remediation. Additionally, the Mission Support Council—an Agency-level governance council that focuses on mission-enabling decisions—has approved funding to upgrade and enhance the enterprise IT security tools used across NASA.

Continuous Monitoring Capabilities

NASA's continuous monitoring cybersecurity capabilities were at 93 percent at the end of FY 2014, slightly below the target of 95 percent, and OCIO anticipates full completion of the target implementation in early FY 2015. Continuous monitoring is a cybersecurity approach that monitors ongoing network performance and configuration and compares it to specific standards, business logic, and known vulnerabilities. The continuous monitoring generates data and alerts that allow NASA to identify, report on, and quickly resolve problems. NASA will continue to work to reach full operational capability over the next two years. The enterprise effort is supported by NASA's implementation of the Department of Homeland Security's (DHS') Continuous Diagnostics and Mitigation capabilities as these capabilities are rolled out in FY 2015. OCIO has developed and registered an Agency Information Security Continuous Monitoring strategy with DHS to describe the Agency's approach to achieve the required continuous monitoring capability.

Strong Authentication

In support of the cross-agency priority (CAP) goal for Cybersecurity, NASA achieved 78 percent compliance for strong authentication using personal identity verification (PIV) authentication for Windows systems. PIV authentication, provided through smartcards, provides multifactor authentication that

is more secure than passwords alone. NASA identified a solution to PIV-enable Mac and Linux machines and is formulating the related PIV authentication rollout strategy and funding model.

Trusted Internet Connection Capabilities

In support of the CAP goal for Cybersecurity, NASA's Trusted Internet Connection (TIC), which is led by DHS, is operating at the 99 percent target level. The TIC initiative is optimizing and standardizing external network connections, including connections to the Internet, used by the Federal Government. The goal is to reduce and consolidate external Internet connections and provide centralized gateway monitoring at TIC Access Providers, improving cybersecurity and incident response.

TIC 2.0 Capabilities

NASA's TIC 2.0 capabilities remained at 89 percent in FY 2014. As part of this effort, OCIO completed implementation of Internet Protocol version 6 (IPv6), a communication protocol used to direct most of the traffic on the Internet. OCIO anticipates completing the full target for the TIC 2.0 CAP goal during FY 2015.

Performance Improvement Plan

OCIO will meet the target for Continuous Monitoring Capabilities by the end of the second quarter of FY 2015, and it will complete the target for TIC 2.0 capabilities in FY 2015. OCIO anticipates addressing all currently known risks to this performance goal.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Identify new tools and technologies needed to support automated security and privacy systems.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-17 Green
Planned Future Performance						
For FY 2015: AMO-15-16: Plan and implement security technology upgrades for the Security Operations Center (SOC).						
For FY 2016: AMO-16-17: Plan and implement Continuous Diagnostics & Mitigation (CDM) tools and technologies into the NASA environment.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Achieve 95 percent implementation of continuous monitoring cybersecurity capabilities.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-19 Yellow
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Explanation of Rating

NASA's continuous monitoring capabilities were at 93 percent at the end of FY 2014. As a result, NASA rated AMO-14-19 yellow. OCIO will meet the 95 percent target for Continuous Monitoring Capabilities by the end of the second quarter of FY 2015. NASA will continue to work to reach full operational capability over the next two years.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Achieve 50 percent implementation of strong authentication cybersecurity capabilities.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-23 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Achieve 99 percent implementation of Trusted Internet Connection consolidation cybersecurity capabilities.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-24 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Achieve 100 percent implementation of Trusted Internet Connection 2.0 cybersecurity capabilities.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-25 Yellow
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Explanation of Rating

OCIO completed implementation of IPv6. At the end of FY 2014, TIC 2.0 capabilities were at 89 percent, resulting in a yellow rating for AMO-14-25. In early FY 2015, OCIO received additional resources to continue implementing the TIC 2.0 capabilities and ensure critical business and mission systems receive priority for use of IPv6-capable TICs. TIC 2.0 capabilities improved to 91 percent as OCIO increased resources to complete a Security Operations Center Sensitive Compartmented Information Facility and other requirements. OCIO will address enterprise firewall and enterprise virtual private network, or VPN, capabilities. OCFO anticipates completing the full target for the TIC 2.0 cross-agency priority goal during FY 2015.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: AMO-15-25: Increase the security of NASA's information operations by implementing the FY 2015 target cross-agency priority cybersecurity capabilities, including Information Security Continuous Monitoring (ISCM), Identity, Credential, and Access Management (ICAM), and Anti-Phishing & malware defense.						
For FY 2016: AMO-16-25: Increase the security of NASA's information operations by implementing the FY 2016 target cross-agency priority cybersecurity capabilities, including Information Security Continuous Monitoring (ISCM), Identity, Credential, and Access Management (ICAM), and Anti-Phishing & malware defense.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Identify viable alternatives to support Federal and Agency mobility goals, supporting Work from Anywhere (WFA).	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	3.3.2 Green
Planned Future Performance				
This performance goal continues through FY 2015.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services			

FY 2014 Performance Results

The NASA Office of the Chief Information Officer (OCIO) is on track to achieve this performance goal to support NASA's Work from Anywhere initiative. During FY 2014, OCIO deployed Microsoft ActiveSync to enable managed mobile device access to NASA email and calendaring services. Looking ahead, OCIO also performed sandbox testing of top vendors for NASA's long-term mobile device management solution. Based on sandbox testing results, OCIO selected a solution and is working to implement the solution as a production service. As no vendor's solution completely meets Federal Identity, Credential, and Access Management (ICAM) requirements, NASA spent the fourth quarter of FY 2014 working with the Mobile Device Management solution vendor, NASA's Center for Internal Mobile Applications, and the internal ICAM team on an approach to meet ICAM requirements. On September 30, 2014, the long-term Mobile Device Management project passed the Test Readiness Review stage and NASA initiated a Mobile Device Management pilot deployment.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Implement a Mobile Device Management (MDM) capability to support access to NASA email and calendaring services from government and personally owned mobile devices.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-18 Green
Planned Future Performance						
For FY 2015: AMO-15-17: Publish the target architecture for Work from Anywhere (WFA) implementation with specific portfolio roadmaps and details.						
For FY 2016: No API this fiscal year						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Consolidate and centralize the management of information technology (IT) enterprise services for end user services, communications, and enterprise applications.	5.2.2.1 Green	5.2.2.1 Green	5.2.2.1 White	3.3.3 Green
Planned Future Performance				
This performance goal does not continue past FY 2014.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services			

FY 2014 Performance Results

The information technology (IT) enterprise services for end user services, communications, and enterprise applications have been consolidated and are in operational status. The transition of Web applications by the Web Services Program to a centralized cloud platform is effectively reducing operations and maintenance costs while improving upon the IT security of the legacy application platforms.

The NASA Office of the Chief Information Officer (OCIO) migrated 158 Web applications into the production cloud environment managed by the Web Enterprise Service Technologies Prime (WESTPrime) contract. Following these migrations, OCIO's focus shifted to the consolidation and decommissioning of applications and Web sites, decommissioning 45 applications that no longer were relevant for their programs or consolidating them into other existing Web sites and applications. These efforts led to a $3 million decrease in operations and maintenance costs as compared to FY 2013. Furthermore, the migration of NASA Headquarters' applications to the centralized environment reduced the Headquarters' data center footprint by 60 percent.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Transition 150 Web applications to the cloud.	No API this fiscal year	10IT02 Green	AMO-11-12 Yellow	AMO-12-12 Green	AMO-13-7 White	AMO-14-29 Green
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: No API this fiscal year						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
By 2015, reduce the number of data centers to 22.	5.2.2.4 Green	5.2.2.4 Yellow	5.2.2.4 White	3.3.4 Yellow
Planned Future Performance				
This performance goal continues through FY 2015.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services			

FY 2014 Performance Results

NASA continues to make progress toward achieving this performance goal. Since the beginning of the effort to reduce the number of data centers, the Office of the Chief Information Officer (OCIO) has closed 26 of the 59 advertised data centers, resulting in 28,892 square feet of white space closed for disposal or repurposing.

During FY 2014, OCIO completed only three of the five originally planned data center closures, resulting in a yellow rating for this performance goal. OCIO is mitigating challenges facing data center consolidation efforts resulting from changes to Center construction plans or facility modifications.

Performance Improvement Plan

OCIO will close a data center at NASA's Langley Research Center in FY 2016. This will allow the data center to be consolidated into Langley's new Computation Research Facility, eliminating the need to move the capability twice. After a cost-benefit analysis, OCIO also postponed a data center consolidation at Kennedy Space Center until the opening of the new Kennedy Data Center in FY 2015.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Maintain the FY 2014 schedule of five data center consolidations contained in NASA Federal Data Center Consolidation Plan.	No API this fiscal year	No API this fiscal year	AMO-11-15 Green	AMO-12-15 Green	AMO-13-8 White	AMO-14-7 Yellow
Planned Future Performance						
For FY 2015: AMO-15-18: Maintain the FY 2015 schedule of ten data center consolidations contained in NASA Federal Data Center Consolidation Plan.						
For FY 2016: No API this fiscal year						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Explanation of Rating

During FY 2014, OCIO completed three of the five originally planned data center closures: the Mission Operations Directorate's Office Automation Data Center at Johnson Space Center, the Flight Simulation Facility at Langley Research Center (LaRC), and the Advanced Computing Concepts Laboratory at Glenn Research Center. OCIO postponed closure of two data centers; as a result, NASA rated AMO-14-7 yellow.

The data center closures that shifted beyond FY 2014 included the Computational Fluid Dynamic Data Center at LaRC and the Space Station Processing Facility Data Center at the Kennedy Space Center (KSC). OCIO will close the LaRC data center in FY 2016 to allow its consolidation into a new Computation Research Facility, eliminating the need to move the capability twice. Based on a cost-benefit analysis, OCIO has postponed the KSC consolidation until the opening of the new Kennedy Data Center in FY 2015.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Does not trend to FY 2014.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	None
Planned Future Performance				
For FY 2015 and FY 2016: 3.3.5: 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.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services			

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: AMO-15-26: Complete the Mission Next Generation Architecture (MNGA).						
For FY 2016: AMO-16-26: Complete the Consolidated Network Operations System (CNOS) Project.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Does not trend to FY 2014.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	None
Planned Future Performance				
For FY 2015 and FY 2016: 3.3.6: Enhance NASA's data management through open data actions, research and development data access, and new data modeling and technologies.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services			

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: AMO-15-27: Provide access to high-quality data that is available and accessible to spur innovation.						
For FY 2016: AMO-16-27: Provide information architecture to manage NASA's data more efficiently.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: AMO-16-28: Provide hosting and data infrastructure for R&D data and publications.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Does not trend to FY 2014.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	None
Planned Future Performance				
For FY 2015 and FY 2016: 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.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services			

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: AMO-15-29: Onboard two significant communities into the cloud in FY 2015.						
For FY 2016: AMO-16-29: Onboard two significant communities into the cloud in FY 2016.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Does not trend to FY 2014.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	None
Planned Future Performance						
For FY 2015: No API this fiscal year						
For FY 2016: AMO-16-30: Implement at least one new technology solution that improves efficiency and the effectiveness of end user service delivery to NASA's workforce.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Agency IT Services					

Strategic Objective 3.4

Ensure effective management of NASA programs and operations to complete the mission safely and successfully.

Lead Office
Office of Safety and Mission Assurance (OSMA); Office of the Chief Engineer (OCE); and Office of the Chief Health and Medical Officer (OCHMO).

Goal Leader
Hal Bell, Deputy Chief, Office of Safety and Mission Assurance

Contributing Programs
Program elements consist of work managed by OCE, OSMA, and OCHMO.

Budget for Strategic Objective 3.4

Budget Authority (in $ millions)	Actual FY 2014	Enacted FY 2015	Requested FY 2016	Notional FY 2017	FY 2018	FY 2019	FY 2020
Total Budget	$179	---	$167	$169	$172	$174	$177

Note: For explanation of budget table, please see the "How to Read the Strategic Review Information" section in the introduction to Part 3.

Vision for Success in 10 Years
Safety and Mission Success (SMS) programs will be successful if NASA protects the health and safety of the NASA workforce and improves the likelihood that NASA's programs, projects, and operations are completed safely and successfully.

Update of Progress Toward Strategic Objective
The NASA 2014 Strategic Review found that:

- SMS contributes to the Agency's safety and success by establishing applicable safety, engineering and health policy directives and procedural requirements and assuring they are appropriately implemented. All NASA policies and procedures are completely reviewed and revised as needed on a five-year cycle.
- Throughout the next 10 years, discipline experts will continue to analyze the criticality of technical, safety, and health risks and evaluate risk acceptability through an established process of independent reviews and assessments. The information and advice from these experts provide important knowledge used by the technical authorities to develop authoritative decisions related to the application of requirements within programs and projects.
- Although some evaluations and elements are being delayed, SMS will be able to continue its critical work.

FY 2014 achievements included the following:

- Zero fatalities or permanent disabling injuries to the public resulted from NASA activities.
- NASA maintained a Total Case Rate and Lost Time Case Rate that exceeded the goals of the President's Protecting Our Workers and Ensuring Reemployment initiative.
- Non-mission failure damage to NASA assets was reduced.
- 100 percent of Category 1 and 2 projects used Agency Safety and Mission Success policy, procedures and independent assessments focused on both technical and programmatic mission success; and 100 percent of the engineering and programmatic workforce had access to the standards and knowledge base needed to maintain and build their skills.
- Highlighted achievements during FY 2014 are detailed in the NASA FY 2014 Agency Financial Report.

Next Steps

Additional details on the strategies for this strategic objective can be found in the NASA 2014 Strategic Plan.

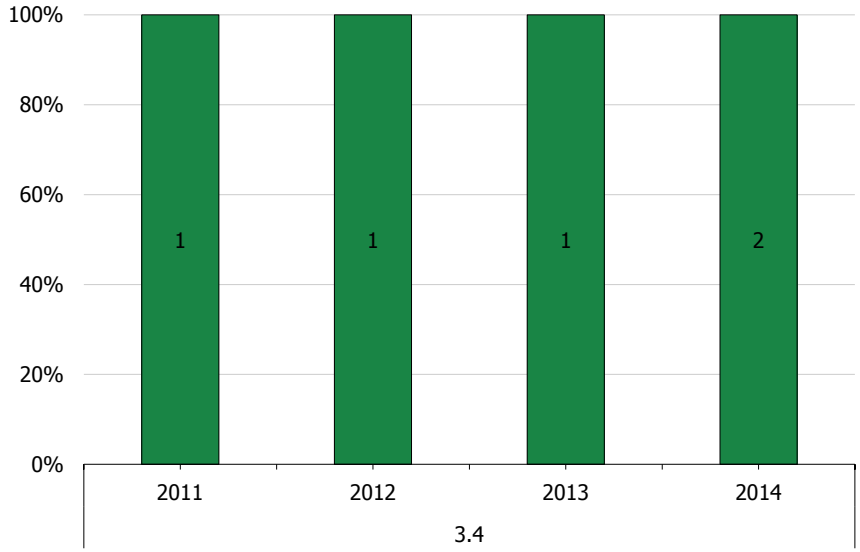
Next Steps in FY 2015

SMS will continue to ensure effective management of NASA programs and operations to complete the Mission safely and successfully. Discipline experts will continue to analyze the criticality of technical, safety, and health risks and evaluate risk acceptability through an established process of independent reviews and assessments.

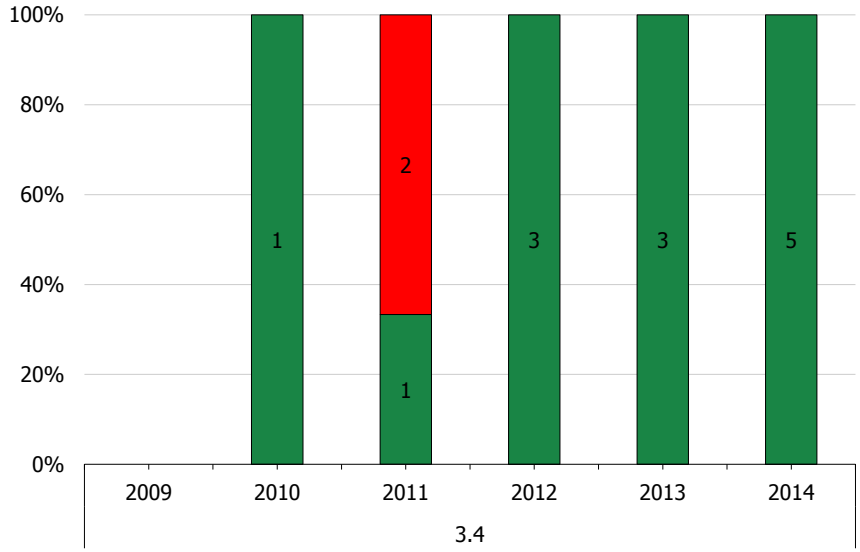
FY 2014 Performance Measures

Strategic Objective 3.4: Ensure effective management of NASA programs and operations to complete the mission safely and successfully.	
Performance Goal 3.4.1: 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.	Performance Goal 3.4.2: Implement the policies, procedures and oversight to continuously improve the probability of technical and programmatic mission success.
Annual Performance Indicators	
• AMO-14-4: Assure zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2014. • AMO-14-5: Maintain a Total Case Rate and Lost Time Case Rate that meets or exceeds the goals of the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative. • AMO-14-6: Reduce damage to NASA assets (excluding launched flight hardware) by two percent during FY 2014, based on a five-year running average (that also excludes launched flight hardware).	• AMO-14-15: 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. • AMO-14-16: 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.

Performance Goal Ratings for Strategic Objective 3.4, FY 2011 through FY 2014



Annual Performance Indicator Ratings for Strategic Objective 3.4, FY 2009 through FY 2014



Past fiscal years do not include performance measures that do not trend to the current fiscal year annual performance indicators.

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
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.	5.2.1.1 Green	5.2.1.1 Green	5.2.1.1 Green	3.4.1 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Safety and Mission Success			

FY 2014 Performance Results

NASA assured the safety and health of its activities and reduced the damage to its assets in FY 2014. This was demonstrated by the following: 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 injury/illness goals established in the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative; and the non-mission failure damage costs in FY 2014 were significantly below the five-year running average.

More information is available on NASA's Office of Safety and Mission Assurance Web site.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Assure zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2014.	No API this fiscal year	10SMS01 Green	AMO-11-9 Green	AMO-12-9 Green	AMO-13-4 Green	AMO-14-4 Green
Planned Future Performance						
For FY 2015: AMO-15-19: Assure zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2015.						
For FY 2016: AMO-16-19: Assure zero fatalities or permanent disabling injuries to the public resulting from NASA activities during FY 2016.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Safety and Mission Success					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Maintain a Total Case Rate and Lost Time Case Rate that meets or exceeds the goals of the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative.	No API this fiscal year	No API this fiscal year	AMO-11-10 Red	AMO-12-10 Green	AMO-13-5 Green	AMO-14-5 Green
Planned Future Performance						
For FY 2015: AMO-15-20: Maintain a Total Case Rate and Lost Time Case Rate that meets or exceeds the goals of the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative.						
For FY 2016: AMO-16-20: Maintain a Total Case Rate and Lost Time Case Rate that meets or exceeds the goals of the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Safety and Mission Success					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: Reduce damage to NASA assets (excluding launched flight hardware) by two percent during FY 2014, based on a five-year running average (that also excludes launched flight hardware).	No API this fiscal year	No API this fiscal year	AMO-11-11 Red	AMO-12-11 Green	AMO-13-6 Green	AMO-14-6 Green
Planned Future Performance						
For FY 2015: AMO-15-21: Reduce damage to NASA assets (excluding launched flight hardware) by two percent during FY 2015, based on a five-year running average (that also excludes launched flight hardware).						
For FY 2016: AMO-16-21: Reduce damage to NASA assets (excluding launched flight hardware) in FY 2016 to a level less than the historical annual average.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Safety and Mission Success					

Performance Goal	FY 2011	FY 2012	FY 2013	FY 2014
Implement the policies, procedures and oversight to continuously improve the probability of technical and programmatic mission success.	No PG this fiscal year	No PG this fiscal year	No PG this fiscal year	3.4.2 Green
Planned Future Performance				
This performance goal continues through FY 2015 and FY 2016.				
Contributing Theme: Agency Management and Operations	**Contributing Program:** Safety and Mission Success			

FY 2014 Performance Results

NASA is implementing the policies, procedures, and oversight necessary to continuously 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 2014, 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 also were 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 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 achieve or maintain their project manager certification requirements.

Find out more about NASA's Office of the Chief Engineer, Office of the Chief Health and Medical Officer, and Office of Safety and Mission Assurance.

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 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.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-15 Green
Planned Future Performance						
For FY 2015: AMO-15-22: 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.						
For FY 2016: AMO-16-22: 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.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Safety and Mission Success					

Annual Performance Indicator	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
For FY 2014: 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.	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	No API this fiscal year	AMO-14-16 Green
Planned Future Performance						
For FY 2015: AMO-15-23: 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.						
For FY 2016: AMO-16-23: 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.						
Contributing Theme: Agency Management and Operations	**Contributing Program:** Safety and Mission Success					