SUBCOMMITTEE ON SPACE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

An Overview of the Budget Proposal for the National Aeronautics and Space Administration for Fiscal Year 2016

Thursday, April 16, 2015
9:00 a.m. – 11:00 a.m.
2318 Rayburn House Office Building

Purpose

The Space Subcommittee will hold a hearing entitled *An Overview of the Budget Proposal for the National Aeronautics and Space Administration for Fiscal Year 2016* on Thursday, April 16, 2015 in Room 2318 of the Rayburn House Office Building. The purpose of the hearing is to review the Administration's fiscal year 2016 (FY16) budget request for the National Aeronautics and Space Administration (NASA) and examine its priorities and challenges.

Witness

The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration

Background

NASA is the world's leading civilian space agency; it employs approximately 17,400 civil servants and supports thousands more through contract work. In addition to its headquarters, the agency operates nine federal research facilities; Goddard Space Flight Center in Greenbelt, MD; Kennedy Space Center in Merritt Island, FL; Langley Research Center in Hampton, VA; Glenn Research Center in Cleveland, OH; Johnson Space Center in Houston, TX; Ames Research Center in Mountain View, CA; Armstrong Flight Research Center at Edwards Air Force Base, CA; Marshall Space Flight Center in Huntsville, AL; and Stennis Space Center in Bay St. Louis, MS. The Jet Propulsion Laboratory (JPL) in Pasadena, CA is a NASA-sponsored Federally Funded Research and Development Center operated by the California Institute of Technology. NASA also owns the Wallops Flight Facility in Wallops Island, Virginia, and the Michoud Assembly Facility east of New Orleans, Louisiana.

The President's FY16 budget request was released on Monday, February 2, 2015. NASA is requesting $18.53 billion, an increase of $519 million over what was appropriated for the agency in FY15. For each of the fiscal years 2016 – 2019, the budget topline request includes modest increases for inflation (one-and-a-half percent). The agency considers the out-year funding levels to be "notional."

Budget Request

Budget Authority ($ in millions)	Actual 2014	Enacted 2015	Request FY16	FY15 vs FY16	Notional 2017	2018	2019	2020
NASA Total	17,646.5	18,010.2	18,529.1	518.9	18,807.0	19,089.2	19,375.5	19,666.1
Science	5,148.2	5,244.7	5,288.6	43.9	5,367.9	5,488.4	5,530.2	5,613.1
Earth Science	1,824.9	-	1.947.3	-	1,966.7	1,988.0	2,009.3	2,027.4
Planetary Science	1,345.7	-	1,361.2	-	1,420.2	1,458.1	1,502.4	1,527.8
Astrophysics	678.3	-	709.1	-	726.5	769.5	1,005.5	1,138.3
James Webb Space Telescope	658.2	645.4	620.0	(25.4)	569.4	534.9	305.0	197.5
Heliophysics	641.0	-	651.0	-	685.2	697.9	708.1	722.1
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Aeronautics	566.0	651.0	571.4	(79.6)	580.0	588.7	597.5	606.4
Space Technology	576.0	596.0	724.8	128.8	735.7	746.7	757.9	769.3
Exploration	4,113.2	4,356.7	4,505.9	149.2	4,482.2	4,298.7	4,264.7	4,205.4
Exploration Systems Development	3,115.2	3,245.3	2,862.9	(382.4)	2,895.7	2,971.7	3,096.2	3,127.1
Commercial Spaceflight	696.0	805.0	1,243.8	438.8	1,184.8	731.9	173.1	1.1
Exploration Research and Dev	302.0	306.4	399.2	92.8	401.7	595.1	995.4	1,077.2
Space Operations	3,774.0	3,827.8	4,003.7	175.9	4,191.2	4,504.9	4,670.8	4,864.3
International Space Station	2,964.1	-	3,105.6	-	3,273.9	3,641.0	3,826.0	4,038.3
Space & Flight Support	809.9	-	898.1	-	917.3	863.8	844.8	826.1
Education	116.6	119.0	88.9	(30.1)	90.2	91.6	93.0	94.4
Safety, Security, and Mission Services	2,793.0	2,758.9	2,843.1	84.2	2,885.7	2,929.1	2,973.0	3,017.5
Center Management and Ops	2,041.5	-	2.075.2	-	2,105.0	2,136.6	2,168.6	2,201.0
Agency Management and Ops	751.5	-	767.9	-	780.7	792.5	804.4	816.5
Construction & Enviromental Compliance & Restoration	522.0	419.1	465.3	46.2	436.1	442.6	449.3	456.0
Construction of Facilities	455.9	-	374.8	-	344.3	349.3	354.6	359.9
Environmental Compliance and Restor	66.1	-	90.5	-	91.8	93.3	94.7	96.1
Office of Inspector General	37.5	37.0	37.4	0.4	38.0	38.5	39.1	39.7
NASA Total	17,646.5	18,010.2	18,529.1	518.9	18,807.0	19,089.2	19,375.5	19,666.1

This year's request contains several items of note:

1. While Congress has consistently appropriated roughly $1.2 billion each year for the past three years on the development of the Orion crew vehicle to ensure Orion remains on schedule, NASA has requested approximately $100 million less for the third year in a row.
2. Congress had made clear in appropriation and authorization legislation that the Space Launch System is a top priority of the Human Exploration program, yet for the fourth year in a row, the Administration has reduced the budget request for this vital national asset. The FY16 budget request seeks a reduction of $343.5 million for launch vehicle development compared with the FY15 appropriation.
3. Although widely critiqued by its own advisory committees, NASA is requesting $220 million to continue work on the Asteroid Robotic Redirect Mission.

4. The budget request proposes funding the formulation of a Europa mission at $30 million. This is only the second year that the Administration has requested funding for this mission despite guidance from the Decadal Surveys and Congressional direction that it be included in the agency's planetary science program. Congress added $75 million in FY13, $80 million in FY14, and $100 million in FY15 for Europa studies and pre-formulation activities.
5. NASA requested $1.243 billion for the Commercial Crew program to procure crew access to the International Space Station (ISS). NASA's current contract with Russia to purchase seats for astronauts for roughly $75 million expires on 2017. NASA recently started negotiating a follow-on contract to procure services after 2017 in the event that the Commercial Crew contractors are unable develop domestic capabilities by that target date.

Asteroid Redirect/Retrieval Mission

As part of the President's budget request for FY14, NASA announced the development of a new mission concept it referred to as the "Asteroid Redirect Mission," (ARM). The original mission concept proposed to capture and redirect a small near-Earth asteroid (NEA) of 7-10 meters in size to a deep retrograde lunar orbit. The mission concept has been altered significantly since it was first proposed. The mission now calls for a robotic probe to visit an NEA in its native orbit and retrieve a smaller boulder from the surface of that asteroid. The probe would then carry the rock into a lunar orbit to be visited by astronauts using the Orion crew vehicle. This is in contrast to the original proposal to capture an asteroid in its native orbit to be "tugged" to lunar orbit. NASA has never attempted this type of sample capture and return. The OSIRIS-REx mission, to be launched next year, will attempt to capture approximately 60 grams of regolith from the asteroid, Bennu, and return it to Earth robotically for less than one billion dollars.

Although the mission concept has changed dramatically, the Administration continues to request funding for elements common to both the original and revised concept. The Administration again requested funding to search for an appropriate asteroid based on size, composition, and orbit, commonly referred to as "identifying and characterizing." This activity will be carried out by the Science Mission Directorate. Next, NASA intends to develop the robotic spacecraft necessary to capture and move the boulder into lunar orbit. This will largely be tasked to the Human Exploration and Operations Mission Directorate. Finally, the development of high-power solar electric propulsion (SEP) will be necessary for travel to the asteroid and then transfer it to lunar orbit. This effort would be conducted by the Space Technology Mission Directorate.

The original mission concept was based on a study by the Keck Institute for Space Studies (Keck Study) at the California Institute of Technology in partnership with the Jet Propulsion Laboratory. NASA Associate Administrator Robert Lightfoot recently stated the robotic part of ARM would fit within a cost cap of $1.25 billion, excluding the launch vehicle and other

leveraged costs.[1] When the Administration released last year's budget request, NASA planned to provide a more detailed budget profile for this mission by the summer of 2014. NASA completed the mission formulation review last February, but still has not provided a detailed budget profile and full development plan for the mission to Congress. Despite recommendations from NASA Advisory Committees that call for an independent cost estimate of the mission options, NASA has refused to conduct such an assessment. Additionally, the NAC recently proposed a finding that NASA would be better served by utilizing an SEP demonstration for a Mars mission rather than ARM.

In December 2012, the National Academy of Sciences released a report about NASA's strategic direction. That report stated "[t]he committee has seen little evidence that a current stated goal for NASA's human spaceflight program—namely, to visit an asteroid by 2025—has been widely accepted as a compelling destination by NASA's own workforce, by the nation as a whole, or by the international community. On the international front there appears to be continued enthusiasm for a mission to the Moon but not for an asteroid mission."[2] The NASA Authorization Act of 2010 required NASA to contract with the National Academies of Science to review the future of human spaceflight.[3] That report found that several components of the ARM concept were considered "dead-end mission elements" that would not benefit NASA in developing the necessary skills and technologies to get humans to Mars.[4]

The Small Bodies Assessment Group, NASA's own advisory group focused on near Earth objects (NEO), found the ARM proposal "to be very interesting and entertaining," but that, "it was not considered to be a serious proposal."[5] Additionally, the NASA Advisory Council has warned that without a full understanding of the proposal, there is the potential that "a mission of significant cost and technical risk may be implemented without a full understanding of the potential for significant cost overrun or schedule slip."[6]

The Administration's FY 2016 request for the Asteroid Redirect Mission totals $220 million, and includes funds dispersed throughout the mission directorates. The request includes $94 million ($56 million of which would be leveraged) in the Human Exploration and Operations Mission Directorate for ARM formulation and in-space robotic servicing and EVA suits; $69 million in the Space Technology Mission Directorate (all of which would be leveraged) for high-powered solar electric propulsion development; $50 million in the Science Mission Directorate (all of

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[1] Jeff Foust, "NASA's Choice for Asteroid Redirect Mission May Not Sway Skeptics." SpaceNews, March 27, 2015. Retrieved at http://spacenews.com/nasas-choice-for-asteroid-redirect-mission-may-not-sway-skeptics/.

[2] Committee on NASA's Strategic Direction; Division on Engineering and Physical Sciences; National Research Council, "NASA's Strategic Direction and the Need for a National Consensus." 2012. Retrieved at http://www.nap.edu/catalog.php?record_id=18248

[3] NASA Authorization Act of 2010 (P.L. 111-267): http://www.gpo.gov/fdsys/pkg/PLAW-111publ267/pdf/PLAW-111publ267.pdf

[4] Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration, http://www.nap.edu/catalog.php?record_id=18801

[5] Findings of the Small Bodies Assessment Group meeting, Small Bodies Assessment Group, finding number three, March 20, 2013. Retrieved at http://www.lpi.usra.edu/sbag/findings/.

[6] NASA Advisory Council Recommendation, Asteroid Redirect Mission, 2014-02-02 (Council-02) http://www.nasa.gov/sites/default/files/files/SquyresLetterToBolden_tagged.pdf

which would be leveraged) for planetary science research and near-Earth object observations; and $7 million for the Chief Technologist for Asteroid Grand Challenge prizes.

Human Exploration and Operations Mission Directorate

Budget Authority ($ in millions)	Actual 2014	Enacted 2015	Request 2016	FY15 vs FY16	Notional 2017	2018	2019	2020
Exploration	4,113.2	4,356.7	4,505.9	149.2	4,482.2	4,298.7	4,264.7	4,205.4
Exploration Systems Development	3,115.2	3,245.3	2,862.9	(382.4)	2,895.7	2,971.7	3,096.2	3,127.1
Commercial Spaceflight	696.0	805.0	1,243.8	438.8	1,184.8	731.9	173.1	1.1
Exploration Research & Development	302.0	306.4	399.2	92.8	401.7	595.1	955.4	1,077.2
Space Operations	3,774.0	3,827.8	4,003.7	175.9	4,191.2	4,504.9	4,670.8	4,864.3
International Space Station	2,964.1	-	3,105.6	-	3,273.9	3,641.0	3,826.0	4,038.3
Space and Flight Support	809.9	-	898.1	-	917.3	863.8	844.8	826.1

The Human Exploration and Operations Mission Directorate is responsible for five broad human spaceflight areas at NASA; Exploration Systems Development, Commercial Spaceflight, Exploration Research and Development, International Space Station, and Space & Flight Support. NASA is requesting an increase of $149.2 million (3.4 percent) in the Exploration account and an increase of $175.9 (4.6 percent) in the Space Operations Account.

Exploration Systems Development

Budget Authority ($ in millions)	Actual 2014	Enacted 2015	Request 2016	FY15 vs FY16	Notional 2017	2018	2019	2020
Exploration	4,113.2	4,356.7	4,505.9	149.2	4,482.2	4,298.7	4,670.8	4,864.3
Exploration Systems Development	3,115.2	3,245.3	2,862.9	(382.4)	2,895.7	2,971.7	3,096.2	3,127.1
Orion Multipurpose Crew Vehic	1,197.0	1,194.0	1,096.3	(97.7)	1,119.8	1,122.9	1,126.7	1,138.0
Space Launch System	1,600.0	1,700.0	1,356.5	(343.5)	1,343.6	1,407.6	1,516.5	1,531.6
Exploration Ground Systems	318.2	351.3	410.1	58.8	432.3	441.2	453.0	457.5

The Exploration Systems Development program is responsible for the design, construction, and integration of the next step in human exploration beyond low Earth orbit (LEO). There are three separate systems that make up the program; the Space Launch System (SLS) heavy lift rocket, the Orion crew vehicle (Orion), and Exploration Ground Systems (EGS). The total request for Exploration Systems Development is $2.86 billion, an 11.7 percent reduction from the FY15 appropriation. In August of 2014, NASA completed a key decision point (KDP-C) in the SLS program that included a cost and schedule commitment. The Administration slipped the launch readiness date for Exploration Mission 1 (EM-1) to November 2018 despite numerous assertions from the Administration that no additional funds beyond previous requests would be needed to keep the SLS and Orion on schedule.

Orion Crew Vehicle – The Orion is the next generation crew vehicle that will carry astronauts beyond LEO. Although Congress has consistently appropriated roughly $1.2 billion for the development of Orion in recent years, NASA requested a reduction in funding for the fourth year in a row. The request of $1.096 billion is a reduction of approximately eight percent from the FY2015 enacted levels. Last December, NASA completed Exploration Flight Test 1 (EFT-1),

which is the first in a series of flight tests for the SLS/Orion systems. EFT-1 was a major success and was the subject of a Subcommittee hearing last December.[7]

Space Launch System – The SLS is the next generation heavy lift launch vehicle that will carry astronauts beyond LEO and will eventually have a 130 ton lift to low-Earth orbit capability. This year's request includes a reduction of approximately $343.5 million (20 percent) relative to the enacted fiscal year 2015 levels, despite insistence from Congress that SLS be a top priority.

Exploration Ground Systems - The Exploration Ground Systems program received an increase in the President's budget request of $58.8 million as a result of continued work at the Kennedy Space Center to ensure the facility is prepared to handle the SLS in 2018. NASA has stated that this work is on track for that launch date. Both the Government Accountability Office and the NASA Inspector General have cautioned that potential schedule risks for the ground systems program could delay EM-1.[8] [9]

Commercial Spaceflight

	Actual	Enacted	Request	FY15 vs	Notional			
Budget Authority ($ in millions)	2014	2015	2016	FY16	2017	2018	2019	2020
Exploration	4,113.2	4,356.7	4,505.9	149.2	4,482.2	4,298.7	4,670.8	4,864.3
Commercial Crew	696.0	-	1,243.8	-	1,184.8	731.9	173.1	1.1
Subtotal, Commercial Spaceflight	696.0	805.0	1,243.8	438.8	1,184.8	731.9	173.1	1.1

With the transition of commercial cargo from development to an operational contract, the Commercial Crew Development Program is the only development effort in the Commercial Spaceflight line.

Commercial Crew – The purpose of this program is to develop a crew transportation system (CTS) that can be procured on a fixed price contract after certification by NASA. While each partner company is investing varying levels of funding to develop these systems, a significant portion of the development costs for each system, as well as their certification for flight to ISS, is being shouldered by NASA. NASA officials have testified before the Committee that the percentage of NASA government funding for the Commercial Crew Program is as high as 90 percent compared to the private sector investment.[10]

In September of last year, NASA awarded services contracts to two of the final competitors in the Commercial Crew Program, the Boeing Company (Boeing) and Space Exploration Technologies Corporation (SpaceX). The final phase of the program, Commercial Crew Transportation Capability (CCtCap) provides significant government funding to finalize designs,

[7] See: http://science.house.gov/hearing/subcommittee-space-hearing-update-space-launch-system-and-orion-monitoring-development

[8] Testimony of Cristina T. Chaplain, Director, Acquisition and Sourcing Management, before the House Committee on Science, Space and Technology, December 10, 2014. http://gao.gov/assets/670/667350.pdf

[9] NASA's Launch Support and Infrastructure Modernization: Assessment of the Ground Systems Needed to Launch SLS and Orion. NASA Office of Inspector General. http://oig.nasa.gov/audits/reports/FY15/IG-15-012.pdf

[10] Testimony of Associate Administrator Bill Gerstenmaier before the House Committee on Science, Space, and Technology, September 14, 2012. Retrieved at http://www.gpo.gov/fdsys/pkg/CHRG-112hhrg76234/pdf/CHRG-112hhrg76234.pdf.

test various elements, and certify each of the crew systems. The firm-fixed price contract guarantees each company at least two flights to the ISS and as many as six for a total of 12 possible flights. The potential contract value is $4.2 billion for Boeing and $2.6 billion for SpaceX.

This year's request includes a significant increase for the program. The request of $1.24 billion is an increase of $438.8 million (55 percent) over FY15. The Administration contends that this increase is required to support two contracts through the certification phase. The Administration has not offered any alternative acquisition model (such as selecting a single contractor) that would fall within historical funding levels for this program. NASA also has not conducted an independent cost estimate for the program.[11]

Exploration Research and Development

	Actual	Enacted	Request	FY15 vs	Notional			
Budget Authority ($ in millions)	2014	2015	2016	FY16	2017	2018	2019	2020
Exploration	4,113.2	4,356.7	4,505.9	149.2	4,482.2	4,298.7	4,670.8	4,864.3
Exploration Research and Dev	302.0	306.4	399.2	92.8	401.7	595.1	995.4	1,077.2
Human Research Program	149.4	-	167.8	-	170.3	178.2	178.2	180.0
Advanced Exploration Systems	152.7	-	231.4	-	231.4	416.9	817.2	897.2

The President's FY16 request for Exploration Research and Development is $399.2 million, an increase of $92.8 million (30 percent) above FY15. NASA's Exploration Research and Development program funds the development of new technologies needed to enable extended human space exploration. The program is comprised of two parts: Human Research Program and Advanced Exploration Systems.

Human Research Program – This program seeks to answer the most difficult questions about extended human operations in space such as the effects of microgravity, radiation, and other related environmental factors on the body. Additionally, this program addresses medical treatment, human factors, and behavioral health support.

Advanced Exploration Systems – This program began in 2012 and represents an approach to developing foundational technologies that will become the building blocks for future space missions. The AES program focuses on crewed systems for deep space, as well as robotic precursor missions to gather critical knowledge about potential destinations in advance of crewed missions.

[11] NASA contracted with Booz|Allen|Hamilton to complete an independent cost assessment of the program which was released on March 1, 2013 and can be found here http://www.nasa.gov/pdf/741617main_CCP-ICA-DRD-2e-Public-Releaseable-Final-Report-3-5-13-508.pdf. However, as noted by the NASA Inspector General (IG), "the assessment found that the estimates were optimistic, and that the Program was likely to experience cost growth. In addition, Booz Allen noted that without costs projected over the life of the Program, NASA officials will not be able to independently evaluate each partner's progress." The IG report also noted that "…despite completion of Preliminary Design Review by NASA's commercial crew partners, Agency officials have yet to develop a life cycle cost estimate for the Program." See "NASA's Management of the Commercial Crew Program," IG-14-001, NASA Office of the Inspector General, November 13, 2013.

Space Operations

Budget Authority ($ in millions)	Actual 2014	Enacted 2015	Request 2016	FY15 vs FY16	Notional 2017	2018	2019	2020
Space Operations	3,774.0	3,827.8	4,003.7	175.9	4,191.2	4,504.9	4,670.8	4,864.3
International Space Station	2,964.1	-	3,105.6	-	3,273.9	3,641.0	3,826.0	4,038.3
Space and Flight Support (SFS)	809.9	-	898.1	-	917.3	863.8	844.8	826.1

The Space Operations Account funds activities for the International Space Station, cargo delivery, and Space Flight and Support. While under a different account, the activities all fall under the Human Exploration and Operations Mission Directorate. The President's budget request for FY16 is $4.003 billion, which represents an increase of $175.9 million (4.6 percent).

International Space Station (ISS) – The ISS is a permanently crewed microgravity laboratory and technology test-bed for exploration and international cooperation. The ISS also includes a National Laboratory for non-NASA and non-governmental users. The NASA Authorization Act of 2010 required NASA to compete a contract for management of the National Laboratory. The Center for the Advancement of Science in Space (CASIS) was subsequently selected for this purpose. In FY14, the Station hosted 368 experiments (28 percent increase). These included 64 in biology and biotechnology, 91 in Earth and space science, 50 educational activities, 36 in human research, 43 in physical science, and 84 in technology.[12]

The ISS Program contains three major projects: Systems Operations and Maintenance (O&M), Research, and Crew and Cargo Transportation. Funding to procure commercial crew or cargo transportation is in the ISS Crew and Cargo Transportation program within the ISS budget. The President's FY16 budget request for the International Space Station is $3.106 billion, an increase of $131.2 million over FY15.

Commercial Cargo - The Commercial Spaceflight program at NASA began in 2006 by funding multiple companies to develop systems for transporting cargo to the ISS with an eye towards eventually having multiple carriers compete for the resupply contract. This was accomplished through the Commercial Orbital Transportation Services (COTS) and Cargo Resupply Services (CRS) programs. At this point, both of the companies involved, Space Exploration Technologies Corporation (or SpaceX) and Orbital-ATK, have successfully delivered cargo to the ISS. While the SpaceX contract includes a down-mass capability (returns cargo to Earth), Orbital-ATK's Cygnus spacecraft (like the European Space Agency's ATV or the Japanese Space Agency's HTV) has no down-mass capability. In 2008, NASA signed two CRS contracts. The SpaceX contract is valued at $1.6 billion for 12 missions and Orbital contract is valued at $1.9 billion for 8 missions.

Space and Flight Support – This program is made up of a number of divisions providing capabilities that play critical roles in several NASA missions including: 21st Century Space Launch Complex, Space Communications and Navigation, Human Space Flight operations,

[12] President's Budget Request for Fiscal Year 2016 for the National Aeronautics and Space Administration, Congressional Justification. P. SO-14. Retrieved at http://www.nasa.gov/sites/default/files/files/FY2016_Budget_Book_508_TAGGED.pdf

Launch Services, and Rocket Propulsion Test. The 21st Century Space Launch Complex program funds modernization at the Kennedy Space Center and Cape Canaveral Air Force Station to benefit multiple users. The Space Communications and Navigation program operates NASA's extensive network of ground-based and orbiting communications hardware and software necessary to receive vast quantities of data generated by NASA's fleet of crewed vehicles and robotic spacecraft. The Human Space Flight Operations (HSFO) program ensures that NASA's astronauts are prepared to safely carry out current and future missions. The Launch Support Program funds various NASA missions that require expendable launch vehicle services. The Rocket Propulsion Test program maintains NASA's wide variety of test facilities for use by NASA, other agencies, and commercial partners.

Science Mission Directorate

Budget Authority ($ in millions)	Actual 2014	Enacted 2015	Request 2016	FY15 vs FY16	Notional 2017	2018	2019	2020
Science	5,148.2	5,244.7	5,288.6	43.9	5,367.9	5,488.4	5,530.2	5,613.1
Earth Science	1,824.9	NA	1,947.3	-	1,966.7	1,988.0	2,009.3	2,027.4
Planetary Science	1,345.7	NA	1,361.2	-	1,420.2	1,458.1	1,502.4	1,527.8
Astrophysics	678.3	NA	709.1	-	726.5	769.5	1,005.5	1,138.3
James Webb Space Telescope	658.2	645.4	620.0	(25.4)	569.4	534.9	305.0	197.5
Heliophysics	641.0	NA	651.0	-	685.2	697.9	708.1	722.1

The Science Mission Directorate (SMD) conducts scientific exploration enabled by the observatories and probes that view Earth from space, observe and visit other bodies in the solar system, and gaze out into the galaxy and beyond. The directorate has four divisions: Earth Science, Planetary Science, Astrophysics and Heliophysics. NASA is requesting $5.288 billion for SMD this year, which is an increase of less than one percent ($43.9 million) above the FY15 enacted.

Earth Science – The Earth Science division at NASA advances the state of Earth system science by advancing the understanding of environmental change through data acquisition, scientific and application research and analysis, and predictive modeling. NASA uses on-orbit satellite missions to provide near real-time data for use by U.S. and international partners for weather forecasting and disaster response. These satellites monitor sea levels and salinity, groundwater depletion rates, sea ice erosion, carbon dioxide levels, and many other phenomena. NASA launched five Earth Science missions in 2014 and the beginning of 2015. The Global Precipitation Measurement (GPM) Core Observatory was launched in early 2014. The mission measures rain and snowfall around the world every three hours. The International Space Station is hosting two Earth Science missions on station: RapidScat replaces QuickScat and gathers data on ocean winds, while the Cloud-Aerosol Transport System (CATS) instrument measures small particle in the atmosphere. The Orbiting Carbon Observatory-2 (OCO-2) was launched in July 2014 and measures carbon dioxide levels in Earth's atmosphere, and replaces the satellite (OCO-1) that was destroyed in a launch failure in 2009. The Soil Moisture Active/Passive (SMAP) mission was launched later than scheduled in January of 2015 and measures soil moisture, contributing to climate research and knowledge of the global water cycle. The NOAA mission

Deep Space Observatory (DSCOVR) (an Earth observation and space weather satellite developed by NASA) was launched in February 2015.

The Administration continues to request a disproportionate amount of funding for Earth Science relative to Planetary Science and Astrophysics (including the James Webb Space Telescope), which have been used to fund other agency priorities such as the National Oceanic and Atmospheric Administration's climate sensors and the US Geologic Survey's moderate resolution land imaging satellite, Landsat. The President is requesting $1.947 billion for Earth Science, an increase of approximately ten percent ($175 million) from FY 2015. This represents a 62.5 percent increase from 2007.

Planetary Science – The Planetary Science division is responsible for monitoring and analyzing data collected from NASA missions exploring the solar system and beyond in the search for the content, origin, and evolution of the solar system as well as the potential for life. Additionally, Planetary Science is responsible for the Near Earth Object Observations program. The Planetary Science division was again targeted this year for budget cuts as the Administration prioritized missions in NASA Earth Science for funding compared to Planetary Science. The FY16 President's Budget Request for Planetary Science is $1.361 billion, down over five percent ($77 million) from the FY15 appropriation.

In 2014, Planetary Science mission highlights included the New Horizons mission "waking up" to be ready for its approach to Pluto. The mission will reach its mission destination in July 2015, and is expected to provide scientists with the first detailed look at dwarf planet Pluto in human history. In the summer of 2014 the ESA/NASA Rosetta comet rendezvous mission reached the Comet Churyumov-Gerasimenko (Comet C-S), and successfully placed the lander, Philae, on the surface. While mainly an ESA mission, NASA scientists contributed to the mission, and will participate in analyzing its data. The historic Dawn spacecraft has successfully been inserted into orbit around the dwarf planet Ceres, after successfully studying the giant asteroid, Vesta. Ceres is the largest object in the asteroid belt between Mars and Jupiter, and this is the first time a mission has successfully orbited two celestial targets. Cassini continues to orbit Saturn, studying its rings and moons, including Titan and Enceladus. This past year, the Curiosity rover on Mars determined Mars was once habitable. In October 2014, NASA's 2001 Mars Odyssey, Mars Reconnaissance Orbiter (MRO), Mars Atmospheric EVolutioN Mission (MAVEN), the Mars rovers, the European Space Agency's orbiter Mars Express, and the Indian Space Research Organization's (ISRO) satellite, and the Mars Orbiter Mission all collected data as Comet Siding Spring made a very close pass by Mars.

Although highly recommended for extended missions by the 2014 Planetary Science Senior Review, the Lunar Reconnaissance Orbiter (LRO) and the Mars Opportunity Rover were not funded in the President's FY16 budget request.

Work continues on the Origins-Spectral-Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-Rex) mission to obtain a sample of near-Earth asteroid Bennu, and the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission to

Mars, both of which are expected to launch in 2016. Work also continues on the Mars 2020 rover, NASA's next flagship mission to Mars.

The President's FY16 budget request includes a line item of $30 million to continue designing a mission to Europa. Congress has long supported the National Academies' recommendation of this mission. The funding request is a decrease of 70 percent ($70 million) of the $100 million Congress appropriated for a Europa mission in FY2015. NASA expects to select instruments for a possible Europa mission in FY15.

Astrophysics – The Astrophysics division analyzes data from NASA missions to understand astronomical events such as the explosion of a star, the birth of a distant galaxy, or the nature of planets circling other stars. The Astrophysics Division operates the Hubble Space Telescope, which continues to provide spectacular science. In 2014 scientists researching data provided from the Kepler space telescope mission confirmed over 1,000 planets outside the Solar System – with over 4,000 awaiting confirmation. NASA approved extending Kepler's mission in 2014, albeit with a modified scientific purpose, following the failure of the reactor wheels used for positioning the space telescope.

The President's FY16 budget request funds the SOFIA mission at $85 million. Last year, the President's budget request significantly under-funded SOFIA, leading the scientific community to believe the mission would be cancelled. Congress appropriated funds to maintain the mission. However, as a caveat to the President's budget request, SOFIA will undergo a senior review this year, which may recommend its cancellation. The SOFIA mission, a unique airborne infrared observatory flown in a modified Boeing 747 airplane above the dust and water vapor of Earth's atmosphere, reached full operational capability in February 2014. Developed and operated in partnership with the German Aerospace Agency (DLR), SOFIA was expected to operate for 20 years. Annual operation costs for SOFIA are roughly $85 million.

The FY16 President's budget request includes $14 million for continued formulation of an AFTA-WFIRST telescope, the follow-on telescope to the James Webb Space Telescope (JWST). This is a decrease of $25.4 million from NASA's FY15 Operation Plan.

The Transiting Exoplanet Survey Satellite (TESS) is given an $8 million increase in the FY16 budget request. TESS is scheduled to launch in 2017, and will hunt for exoplanets. JWST is expected to help characterize planets found by TESS during its scientific survey.

James Webb Space Telescope (JWST) – JWST is the follow on to the Hubble Space Telescope and will be able to stare deep into space picking up the faintest infrared light which could give astronomers and cosmologists new clues into the beginnings of the universe. The telescope will look for answers to questions such as: How did the universe make galaxies? How are stars made? Are there other planets that can support life? JWST was called out by the National Research Council's 2001 Decadal Survey as the top priority of the science community and that priority was reaffirmed by the 2010 Decadal Survey. JWST will be stationed at the Earth-Sun Lagrange point (L_2) approximately 930,000 miles from the Earth and stands three stories high, spanning the size of a tennis court. Beginning in FY12, JWST was taken out of the Astrophysics

division in the budget and was given its own budget line. After an extensive re-planning effort, NASA re-baselined JWST to a total life-cycle cost of $8.8 billion and a launch readiness date of October 2018. Based on this effort, the funding profile for FY13 and beyond increased significantly, with the bulk of the increases in the early years of the re-plan. While a decrease from past years, the President's budget request for FY16 for $620 million is in line with projected development costs. In FY15 and FY16 the main thrust of work will be integrating and testing the instruments, telescope, and spacecraft bus, to prepare it for the October 2018 launch.

Heliophysics – The Heliophysics division seeks to understand the Sun and its interactions with the Earth and the solar system. The goal of the program is to understand the Sun, heliosphere, and planetary environments as a single connected system. The Magnetospheric MultiScale (MMS) mission, designed to investigate how the Earth and Sun's magnetic fields interact, launched in March 2015. In FY16 the Heliophysics Research Program will collect science from 20 active space missions, including IRIS, MMS, and the Voyager 2 spacecraft, among others. Solar Probe Plus, the flagship mission to explore the Sun's outer atmosphere and get closer to the Sun than any previous mission, will conduct its System Integration Review in FY16.

Aeronautics Research Mission Directorate

Budget Authority ($ in millions)	Actual 2014	Enacted 2015	Request 2016	FY15 vs FY16	Notional 2017	2018	2019	2020
Aeronautics	566.0	651.0	571.4	79.6	580.0	588.7	597.5	606.4
Airspace Operations and Safety Program	-	-	142.4	-	153.2	159.6	160.0	163.0
Advanced Air Vehicles Program	-	-	240.9	-	243.2	243.2	231.0	232.8
Integrated Aviation Systems Program	-	-	96.0	-	85.6	89.0	101.6	104.8
Transformative Aeronautics Concepts Prog	-	-	92.1	-	98.0	98.9	104.9	105.8
Aviation Safety	80.0	-	-	-	-	-	-	-
Airspace Systems	91.8	-	-	-	-	-	-	-
Fundamental Aeronautics	168.0	-	-	-	-	-	-	-
Aeronautics Test	77.0	-	-	-	-	-	-	-
Integrated Systems Research	126.5	-	-	-	-	-	-	-
Aeronautics Strategy & Management	22.7	-	-	-	-	-	-	-

NASA's Aeronautics Research Mission Directorate (ARMD) conducts aeronautics research to improve aviation safety, efficiency, and air traffic management, and to develop game-changing technology to facilitate the continued growth of the U.S. aviation industry. The FY16 budget request for ARMD is $571.4 million, a 12 percent decrease ($79.6 million) from the $651 million included in the FY15 appropriations act.

In FY16, NASA will focus on four major goals. First, developing and demonstrating air traffic controller-managed spacing of arriving flights (Thrust 1). This will improve the efficiency of aircraft flows into airports. Second, validating the truss-braced wing (TBW) aircraft design that should reduce transport aircraft fuel consumption (Thrust 2). Third, developing and refining data analytics to provide information about precursors to safety risks (Thrust 5). This advancement in data analytics will also support development of a system that can predict and mitigate emerging risks. Lastly, NASA will test unmanned aircraft systems (UAS) and use data from those tests to deliver UAS recommendations to the Radio Technical Commission for Aeronautics (Thrust 6).

NASA will also continue work on a UAS Traffic Management (UTM) system. These efforts will contribute to the development of the standards necessary to achieve UAS integration into the NAS.

Among the goals highlighted in the request is also the development, transfer, and implementation of new technologies as part of the Next Generation (NextGen) Air Transportation System.

Major changes in the FY16 budget include increasing investment in UAS research (particularly in UTM), increasing funding for low-carbon propulsion-related research, increasing funding for hypersonics research, and transitioning knowledge from the Environmentally Responsible Aviation (ERA) Project to stakeholders after the Project ends in FY15.

Space Technology Mission Directorate

	Actual	Enacted	Request	FY15 vs	Notional			
Budget Authority ($ in millions)	2014	2015	2016	FY16	2017	2018	2019	2020
Space Technology	576.0	596.0	724.8	128.8	735.7	746.7	757.9	769.3
SBIR & STTR	175.0	-	200.9	-	213.0	213.2	213.5	213.8
Agency Technology and Innovation	30.6	-	33.0	-	33.0	33.2	33.2	33.2
Space Technology Research and Development	370.4	-	491.0	-	489.7	500.3	511.2	522.4

The request for the Space Technology Mission Directorate was realigned in this request to include three main programs rather than four. The three programs include Agency Technology and Innovation; Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR); and Space Technology Research and Development. NASA requested $724.8 million this year for Space Technology which is an increase of $128.8 million (21.6 percent) relative to the FY15 enacted funding.

Agency Technology and Innovation – This program is host to the Office of the Chief Technologist (OCT). The Chief Technologist is the principal advisor to the Administrator on matters concerning agency-wide technology policies and programs. The OCT provides strategy and leadership that guides open innovation activities, technology transfer, and commercialization of technologies.

The OCT has four primary functions; strategic technology integration, to enable technology transfer, administer prizes and challenges, and provide analytical support for decision makers on the growth of the entrepreneurial space communities.

SBIR & STTR – The SBIR and STTR programs are required by federal law for federal agencies. These programs fulfill a requirement to support early stage research and development through investments in small businesses. Under the recent SBIR reauthorization, NASA is required to invest three percent of agency research and development dollars relative to extramural agency research and development through these two programs.

Space Technology Research & Development – This program supports early stage conceptual studies that focus on discovering, developing, testing, and demonstrating new technologies. The program supports projects at all technology readiness levels to create a technology pipeline, starting with innovation and resulting in ready-to-utilize technologies that improve the nation's in-space capabilities.

The portfolio includes nine main areas; Game Changing Development, Technology Demonstration Missions, Small Spacecraft Technologies, Space Technology Research Grant, NASA Innovative Advanced Concepts, Center Innovation fund, Centennial Challenges Prize, Small Business Innovation Research & Small Business Technology Transfer, and Flight Opportunities Program. There are also nine major projects identified by NASA as critical within their various program offices. They are referred to as "the big nine", and include: 1) Laser communications; 2) Cryogenic Propellant Storage & Transfer; 3) Deep Space Atomic Clock; 4) Large-Scale Solar Sail; 5) Low Density Supersonic Decelerators; 6) Green Propellants; 7) Human Exploration Telerobotics and Human-Robotics Systems; 8) Solar Electric Propulsion; and 9) Composite Cryotank.

Education

	Actual	Enacted	Request	FY15 vs	Notional			
Budget Authority ($ in millions)	2014	2015	2016	FY16	2017	2018	2019	2020
Education	116.6	119.0	88.9	(30.1)	90.2	91.6	93.0	94.4
Aerospace Rsch & Career Dev	58.0	58.0	33.0	(25.0)	33.0	33.0	33.0	33.0
STEM Education & Accountability	58.6	-	55.9	-	57.2	58.6	60.0	61.4

The President's FY15 request for NASA's Education program is $88.9 million, a 25.3 percent ($30.1 million) decrease from the FY15 enacted levels. The FY16 request is structured to implement the Administration's initiative to reorganize Science, Technology, Engineering and Mathematics (STEM) education programs and activities across the federal government. In FY14 NASA's STEM education activities were unified under the Office of Education. However, an additional $20 million is requested for the Science Mission Directorate to competitively fund the best application of science assets to STEM education goals, in addition to funding the Global Learning and Observations to Benefit the Environment (GLOBE) program at $6 million per year.

The two main programs which make up the Education Mission Directorate are the Aerospace Research & Career Development Program (ARCD) and the STEM Education & Accountability Program (SEA).

Within the ARCD are two specialized grant programs, the National Space Grant College and Fellowship project and the Experimental Project to Stimulate Competitive Research (EPSCoR). NASA Space Grant is a competitive grant program supporting science and engineering education and research efforts for educators and students by leveraging the resource capabilities and technologies of universities, museums, science center, and local governments. The Administration requested $24 million for Space Grant, a program that is consistently

appropriated higher than Administration requests, most recently $40 million for FY15. The second program in ARCD is EPSCoR, which is a competitive grant project that establishes partnerships between government, higher education, and industry to promote research and development (R&D) capacity in individual states or regions. EPSCoR has historically funded regions or states that do not typically participate equitably in federal aerospace and aerospace-related research activities. The Administration request for the EPSCoR was $9 million. The program received $18 million in FY15.

The SEA provides funding for NASA-unique STEM education opportunities, including internships, launch initiatives, and grants, and provides students and educators with NASA's STEM content. There are two main initiatives in SEA, the Minority University Research Education Project (MUREP) and the STEM Education and Accountability Projects (SEAP). MUREP supports multi-year research grants at Historically Black Colleges and Universities, Hispanic Serving Institutions, and Tribal Colleges. Additionally, MUREP funds scholarships, internships, and mentoring for K-12 students. SEAP supports the application of NASA assets, missions, and discoveries to advance the Administration's education goals. NASA intends to work with other agencies to support the goals of the Five-Year Federal Strategic Plan on STEM Education. In FY16 the President's budget requests $55.9 million.

Safety, Security, and Mission Services (SSMS)

	Actual	Enacted	FY15 vs	Request	Notional			
Budget Authority ($ in millions)	2014	2015	FY16	2016	2017	2018	2019	2020
Safety, Security, and Mission Services	2,793.0	2,758.9	84.2	2,843.1	2,885.7	2,929.1	2,973.0	3,017.5
Center Management and Operations	2,041.5	-	-	2,075.2	2,105.0	2,136.6	2,168.6	2,201.0
Agency Management and Operations	751.5	-	-	767.9	780.7	792.5	804.4	816.5

Formerly called Cross Agency Support, SSMS activities include the administration of the agency, operations and maintenance of the NASA Centers, and facilities, including Headquarters, and provide oversight to reduce risk to life and mission for all NASA programs. This includes information technology (IT) infrastructure, security, safety and mission assurance, human capital management, finance, procurement, and engineering. The Administration requested $2.843 billion for SSMS in FY16, an increase of $84.2 million or 3.1 percent.

Construction & Environmental Compliance and Restoration (CECR)

	Actual	Enacted	Request	FY15 vs	Notional			
Budget Authority ($ in millions)	2014	2015	2016	FY16	2017	2018	2019	2020
Construction and Enviro Comp and Rest	522.0	419.1	465.3	46.2	436.1	442.6	449.3	456.0
Construction of Facilities	455.9	-	374.8	-	344.3	349.3	354.6	359.9
Environmental Compiance and Restoration	66.1	-	91.8	-	91.8	93.3	94.7	96.1

The CECR account is comprised of two elements, Construction of Facilities (CoF) and Environmental Compliance and Restoration (ECR). CoF is responsible for making capital repairs and improvements to infrastructure and provides NASA programs with test, research, and

operational facilities that they require to accomplish their missions. About 82 percent of NASA's infrastructure is beyond its constructed design life. ECR is responsible for cleaning up pollutants released into the environment during past activities.

The President's request for FY16 provides an increase to the CECR account of $46.2 million or 11 percent.

Inspector General

Budget Authority ($ in millions)	Actual 2014	Enacted 2015	FY15 vs FY16	Request 2016	Notional 2017	Notional 2018	Notional 2019	Notional 2020
Inspector General	37.5	37.0	0.4	37.4	38.0	38.5	39.1	39.7

The Office of the Inspector General conducts audits, investigations, and reviews NASA programs to prevent and detect waste, fraud, abuse and mismanagement. The Administration requested $37.4 million in FY16, which represents a 1.1 percent increase from previous year funding.