A REVIEW OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION BUDGET FOR FISCAL YEAR 2015

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRTEENTH CONGRESS

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March 27, 2014

A REVIEW OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION BUDGET FOR FISCAL YEAR 2015

Thursday, March 27, 2014

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON SPACE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Committee met, pursuant to call, at 9:04 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Steven Palazzo [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
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EDDIE BERNICE JOHNSON, Texas
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Congress of the United States
House of Representatives
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Subcommittee on Space

A Review of the National Aeronautics and Space Administration Budget for Fiscal Year 2015

Thursday, March 27, 2014
9:00 a.m. to 11:00 a.m.
2318 Rayburn House Office Building

Witness

***The Honorable Charles F. Bolden, Jr.**, Administrator, National Aeronautics and Space Administration (NASA)*

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

An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2015

Thursday, March 27, 2014
9:00 a.m. – 11:00 a.m.
2318 Rayburn House Office Building

Purpose

The purpose of the hearing is to review the Administration's fiscal year 2015 (FY15) budget request for the National Aeronautics and Space Administration and examine its priorities and challenges.

Witness

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

Background

The National Aeronautics and Space Administration is the world's leading civilian space agency; it employs approximately 17,400 civil servants and supports approximately 18,000 people 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; Dryden 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 Corporation 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 budget request was released on March 4, 2014, a month later than federal law mandates.[1] For FY15 NASA is requesting $17.46 billion, a decrease of $185.9 million from the

[1] 31 U.S.C. 1105 (a), The Budget and Accounting Act of 1921, requires that "on or after the first Monday in January but not later than the first Monday in February of each year, the President shall submit a budget of the United States Government for the following fiscal year."

FY14 appropriation. For each of the fiscal years 2015 – 2018, the budget topline request includes modest increases for inflation (one percent). The agency considers the out-year funding levels to be "notional."

Budget Request

Budget Authority ($ in millions)	Actual 2013	Enacted 2014	Request FY15	FY14 Vs FY15	Notional 2016	2017	2018	2019
	16,865.2	17,646.5	17,460.6	(185.9)	17,635.3	17,811.5	17,989.7	18,169.7
Science	4,781.6	5,151.2	4,972.0	(179.2)	5,021.7	5,071.9	5,122.6	5,173.9
Earth Science	1,659.2	1,826.0	1,770.3	(55.7)	1,815.5	1,837.6	1,861.9	1,886.3
Planetary Science	1,274.6	1,345.0	1,280.3	(64.7)	1,304.9	1,337.1	1,355.7	1,374.1
Astrophysics	617.0	668.0	607.3	(60.7)	633.7	651.2	696.8	933.0
James Webb Space Telescope	627.6	658.2	645.4	(12.8)	620.0	569.4	534.9	305.0
Heliophysics	603.2	654.0	668.9	14.9	647.6	676.6	673.3	675.5
Aeronautics	529.5	566.0	551.1	(14.9)	556.6	562.2	567.8	573.5
Space Technology	614.5	576.0	705.5	129.5	712.6	719.7	726.9	734.2
Exploration	3,705.5	4,113.2	3,976.0	(137.2)	4,079.9	4,049.4	4,107.7	3,673.4
Exploration Systems Dev	2,883.8	3,115.2	2,784.4	(330.8)	2,863.3	2,905.9	2,982.1	3,106.6
Commercial Spaceflight	525.0	696.0	848.3	152.3	872.3	791.7	730.9	172.0
Exploration Research & Dev	296.7	302.0	343.4	41.4	344.3	351.8	394.7	394.7
Space Operations	3,724.9	3,778.0	3,905.4	127.4	3,951.9	4,062.8	4,085.6	4,601.8
Space Shuttle	38.8	-	-		-	-	-	-
International Space Station	2,775.9	-	3,050.8		3,126.5	3,266.9	3,290.3	3,818.6
Space & Flight Support	910.2	-	854.6		825.4	795.9	795.3	783.2
Education	116.3	116.6	88.9	(27.7)	89.8	90.7	91.6	92.6
Cross Agency Support	2,711.0	2,793.0	2,778.6	(14.4)	2,806.4	2,834.4	2,862.8	2,891.4
Center Management & Ops	1,991.6	-	2,038.8		2,059.2	2,079.7	2,100.5	2,121.6
Agency Management & Ops	719.4	-	739.8		747.2	754.7	762.3	769.8
Construction & Environmental Compliance & Restoration	646.6	515.0	446.1	(68.9)	379.0	382.7	386.6	390.4
Office of Inspector General	35.3	37.5	37.0	(0.5)	37.4	37.7	38.1	38.5
NASA FY 2014	16,865.2	17,646.5	17,460.6	(185.9)	17,635.3	17,811.5	17,989.7	18,169.7

This year's request contains several items of note:

1. While Congress has consistently required NASA spend no less than $1.2 billion on the development of the Orion crew capsule, NASA has requested approximately $200 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 third year in a row the Administration has reduced the budget for this vital asset. The budget seeks a reduction of $219 million for launch vehicle development.

3. Although the Administration seeks to cut NASA's budget, it nevertheless is requesting $180 million to continue work on the Asteroid Retrieval Mission. The Consolidated Appropriations Act of 2014 directed the Administration to provide more information on this mission before Congress would make a long-term commitment to the endeavor.
4. The budget request proposes funding the formulation of a Europa mission at $15 million for the first time. Congress added $75 million in FY13 and $80 million in FY14 for Europa studies and pre-formulation activities. The budget request does not include funding for the mission in any years beyond FY15.
5. NASA intends to place the Stratospheric Observatory for Infrared Astronomy (SOFIA) project into storage, which greatly concerns our German partners. After a lengthy development, SOFIA only reached its full operational capability in February. NASA stated that retiring SOFIA would save $85 million per year in operating costs that would be better spent on new missions. SOFIA cost $1.2 billion to develop and had an expected mission lifetime of 20 years. NASA funds 75 percent of the operating costs, while DLR, the German space agency, funds the remainder. As part of the international agreement, DLR provided the telescope and NASA provided the airframe.
6. The President's budget request includes an initiative titled the "Opportunity, Growth, and Security Initiative" (OGSI) which seeks to add $855 million to various NASA programs above the budget request. OGSI funding is contingent upon generic spending cuts and tax loophole closures.

Asteroid Redirect/Retrieval Mission

As part of the President's budget request last year, NASA announced the development of a new mission concept it referred to as the "Asteroid Retrieval Mission." The 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 relies on three simultaneous development activities in various Mission Directorates. First, NASA intends 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 or redirect the Asteroid. 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 to reach the object and "tug" it into the appropriate orbit.

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. The Keck Study estimated a mission of this size and scope would cost approximately $2.6 billion.[2] NASA contends that the Keck Study did not take into account existing hardware and development projects already underway by various mission directorates

[2] Brophy, J., Friedman, L., & Culick, F., "Asteroid Retrieval Mission Feasibility Study." Keck Institute for Space Studies, 2012. Retrieved at http://www.lpi.usra.edu/sbag/documents/Asteroid percent20Return percent20Feasibility percent2020120530.pdf.

and that the overall cost will be less than originally projected. When the Administration released last year's budget request, NASA planned to provide a more detailed budget profile for this mission by the summer or 2014. NASA now plans to have a mission formulation review completed by February of 2015.

A year after the introduction of this mission, the Administration still has not provided a detailed mission profile or budget proposal. The Consolidated Appropriations Act of 2014 required NASA to provide additional details about the mission concept before Congress would commit long-term resources to the effort.

In December of 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."[3] Additionally, the Small Bodies Assessment Group, NASA's own advisory group focused on near Earth objects (NEO) found it "to be very interesting and entertaining" but that "it was not considered to be a serious proposal."[4]

Since the original proposal was submitted to Congress, the Administration has modified the concept. Today the mission is commonly referred to as the Asteroid Redirect Mission and includes a "grand challenge" as well as multiple technology development and demonstration efforts. This year the President's budget request includes $180 million to conduct "early development of the asteroid mission, including advancing solar electric propulsion and capture systems, and conduct of the Mission Concept Review in which the mission architecture will be established."

The total request includes $40 million in the Science Mission Directorate for near Earth object observations, $40 million in the Human Exploration and Operations Mission Directorate for mission enabling technology development, $93 million in the Space Technology Mission Directorate for the development of the next generation solar electric propulsion as well as another $7 million for the "Asteroid Grand Challenge."

This request is in addition to the $105 million NASA requested last year for the same project. Without a human exploration roadmap it is uncertain how this mission would fit into the nation's overall space exploration architecture.

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[3] 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

[4] 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/.

Human Exploration and Operations Mission Directorate

Budget Authority ($ in millions)	Actual 2013	Enacted 2014	Request 2015	FY14 vs FY15	Notional 2016	2017	2018	2019
Exploration	**3,705.5**	**4,113.2**	**3,976.0**	**(137.2)**	**4,079.9**	**4,049.4**	**4,107.7**	**3,673.4**
Exploration Systems Dev	2,883.8	3,115.2	2,784.4	(330.8)	2,863.3	2,905.9	2,982.1	3,106.6
Commercial Spaceflight	525.0	696.0	848.3	152.3	872.3	791.7	730.9	172.0
Exploration Research & Dev	296.7	302.0	343.4	41.4	344.3	351.8	394.7	394.7
Space Operations	**3,724.9**	**3,778.0**	**3,905.4**	**127.4**	**3,951.9**	**4,062.8**	**4,085.6**	**4,601.8**
Space Shuttle	38.8	-	-		-	-	-	-
International Space Station	2,775.9	-	3,050.8		3,126.5	3,266.9	3,290.3	3,818.6
Space & Flight Support	910.2	-	854.6		825.4	795.9	795.3	783.2

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 a decrease of $137.2 million (3.3 percent) in the Exploration account and an increase of $127.4 million (3.3 percent) in the Space Operations Account.

Exploration Systems Development

Budget Authority ($ in millions)	Actual 2013	Enacted 2014	Request FY15	FY14 Vs FY15	Notional 2016	2017	2018	2019
Exploration	**3,705.5**	**4,113.2**	**3,976.0**	**(137.2)**	**4,079.9**	**4,049.4**	**4,107.7**	**3,673.4**
Exploration Systems Dev	2,883.8	3,115.2	2,784.4	(330.8)	2,863.3	2,905.9	2,982.1	3,106.6
Orion Crew Capsule	1,113.8	1,197.0	1,052.8	(144.2)	1,096.3	1,119.8	1,122.9	1,126.7
Space Launch System	1,414.9	1,600.0	1,380.3	(219.7)	1,356.9	1,353.8	1,418.0	1,526.9
Exploration Ground Systems	355.1	318.2	351.3	33.1	410.1	432.3	441.2	453.0

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 capsule (Orion), and Exploration Ground Systems (EGS). The total request for Exploration Systems Development is $2.78 billion, a 10.6 percent reduction from the FY14 appropriation. NASA continues to plan for an initial uncrewed test launch of the SLS and Orion in 2017 and maintains that they will stay on schedule with the current funding request.

Orion Crew Capsule – The Orion is the next generation crew capsule that will carry astronauts beyond LEO. Although Congress has consistently appropriated no less than $1.2 billion for the development of Orion, NASA requested a reduction in funding for the fourth year in a row. The request of $1.052 billion is a reduction of approximately 12 percent from the FY2014 enacted levels. NASA recently announced that the launch of a national security payload delayed the launch of Exploration Flight Test 1 (EFT-1), which was set for September of this year. The new launch date will likely be in December of this year.[5]

[5] "Orion Makes Testing, Integration Strides Ahead of First Launch to Space," NASA, March, 14, 2014. Retrieved at http://www.nasa.gov/content/orion-makes-testing-integration-strides-ahead-of-first-launch-to-space-0/#.UzBDJIUWNws.

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 $219.7 million (13 percent) relative to the enacted fiscal year 2014 levels, despite insistence from Congress that SLS be a top priority.

Exploration Ground Systems - The Exploration Ground Systems program received a modest increase as a result of continued work at the Kennedy Space Center to ensure the facility is prepared to handle the SLS in 2017. NASA has stated that this work is on track for that launch date.

Commercial Spaceflight

	Actual	Enacted	Request	FY14 Vs	Notional			
Budget Authority ($ in millions)	2013	2014	FY15	FY15	2016	2017	2018	2019
Exploration	**3,705.5**	**4,113.2**	**3,976.0**	**(137.2)**	**4,079.9**	**4,049.4**	**4,107.7**	**3,673.4**
Commercial Spaceflight	525.0	696.0	848.3	152.3	872.3	791.7	730.9	172.0
Commercial Cargo	-	-	-	-	-	-	-	-
Commercial Crew	525.0	696.0	848.3	152.3	872.3	791.7	730.9	172.0

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 CTS, 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 current phases of the Commercial Crew Program is as high as 90 percent compared to the private sector investment.[6]

For the last four years, Congress appropriated $307.4 million, $392.0 million, $525 million, and $696 million respectively for the program. NASA requested $848.3 million this year, which represents an increase of $152.3 million (21 percent) over FY14.

[6] 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.

Exploration Research and Development

Budget Authority ($ in millions)	Actual 2013	Enacted 2014	Request FY15	FY14 Vs FY15	Notional 2016	2017	2018	2019
Exploration	**3,705.5**	**4,113.2**	**3,976.0**	**(137.2)**	**4,079.9**	**4,049.4**	**4,107.7**	**3,673.4**
Exploration Research and Dev	296.7	302.0	343.4	41.4	344.3	351.8	394.7	394.7
Human Research Program	146.7		160.5		167.8	173.6	178.2	178.2
Advanced Exploration Systems	150.0		182.9		176.5	178.2	216.6	216.6

The President's FY14 request for Exploration Research and Development is $343.4 million, an increase of $41.4 million (13.7 percent) above FY14. 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.

Space Operations

Budget Authority ($ in millions)	Actual 2013	Enacted 2014	Request FY15	FY14 Vs FY15	Notional 2016	2017	2018	2019
Space Operations	**3,724.9**	**3,778.0**	**3,905.4**	**127.4**	**3,951.9**	**4,062.8**	**4,085.6**	**4,601.8**
Space Shuttle Program	38.8	-	-	-	-	-	-	-
International Space Station	2,775.9		3,050.8		3,126.5	3,266.9	3,290.3	3,818.6
Space & Flight Support	910.2		854.6		825.4	795.9	795.3	783.2

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 FY15 is $3.905 billion, which represents an increase of $127.4 million (3.3 percent).

International Space Station (ISS)– The ISS is a permanently crewed microgravity laboratory and technology testbed 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 FY13, the Station hosted 286 experiments. These included 58 in biology and

biotechnology, 34 in Earth and space science, 38 educational activities, 41 in human research, 44 in physical science, and 71 in technology.[7]

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 FY15 budget request for the International Space Station is $3.050 billion, an increase of $274.9 million over FY13.

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 Sciences Corporation (Orbital), have successfully delivered cargo to the ISS. While the SpaceX contract includes a down-mass capability (returns cargo to Earth), Orbital'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, 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.

[7] President's Budget Request for Fiscal Year 2014 for the National Aeronautics and Space Administration, Congressional Justification. P. SO-9. Retrieved at http://www.nasa.gov/pdf/740512main_FY2014%20CJ%20for%20Online.pdf.

Science Mission Directorate

Budget Authority ($ in millions)	Actual 2013	Enacted 2014	Request FY15	FY14 Vs FY15	Notional 2016	2017	2018	2019
Science	**4,781.6**	**5,151.2**	**4,972.0**	**(179.2)**	**5,021.7**	**5,071.9**	**5,122.6**	**5,173.9**
Earth Science	1,659.2	1,826.0	1,770.3	(55.7)	1,815.4	1,837.6	1,861.9	1,886.3
Planetary Science	1,274.6	1,345.0	1,280.3	(64.7)	1,304.9	1,337.1	1,355.7	1,374.1
Astrophysics	617.0	668.0	607.3	(60.7)	633.7	651.2	696.8	933.0
James Webb Space Telescope	627.6	658.2	645.4	(12.8)	620.0	569.4	534.9	305.0
Heliophysics	603.2	654.0	668.9	14.9	647.6	676.6	673.3	675.5

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 $4.972 billion for SMD this year, which is a reduction of approximately $179.2 million (four percent) below the FY14 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 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. Recently, NASA launched Landsat 8 in early 2013 as well as the Global Precipitation Measurement (GPM) mission in February 2014. NASA expects to launch the Soil Moisture Active/Passive (SMAP), the Stratospheric Aerosol and Gas Experiment III (SAGE III), the Deep Space Observatory (DSCOVR), and the Orbiting Carbon Observatory-2 (OCO-2) missions later this year. 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's priorities such as the National Oceanic and Atmospheric Administration's climate sensors and the US Geologic Survey's moderate resolution land imaging satellite.

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 NASA prioritized missions in Earth Science and continued development of the James Webb Space Telescope (JWST). This trend has decreased the Planetary Science division from $1.485 billion in the FY11 request, to $1.280 billion this year.

In 2013, Planetary Science missions went to Mars (Mars Atmosphere & Volatile Evolution) and the Moon (Lunar Atmosphere and Dust Environment Explorer). In 2014 the ESA/NASA

Rosetta comet rendezvous mission woke up from its ten-year journey to the asteroid belt and is expected to arrive at Comet Churyumov-Gerasimenko (Comet C-S) in the summer of 2014. Cassini continues to orbit Saturn, studying its rings and moons, including Titan and Enceladus. 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 budget request includes a line item of $15 million to begin designing a mission to Europa. Congress has long supported the National Academies' recommendation of this mission. The funding request is only for FY15, with no money budgeted for out-year activity. Further development of a mission concept beyond FY15 is uncertain.

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 2013 scientists used Hubble to determine the possible existence of icy plumes of water spouting from the south pole of Jupiter's moon Europa. Scientists researching data provided from the Kepler mission have discovered nearly 1,700 planets outside the Solar System – a dramatic increase in exoplanet discoveries to date. NASA is currently reviewing proposals to continue using Kepler in a new or limited capacity, following the failure of two of its positioning wheels last year.

The President's FY15 budget request does not adequately fund the SOFIA mission, effectively canceling it. The SOFIA mission, a unique airborne infrared observatory flown in a 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 $85 million. NASA's reason for retiring the project is that the mission was originally designed to overlap with Spitzer and Herschel telescopes. The Herschel telescope ceased observations in 2013, and the Spitzer telescope is operating at limited capacity. Without those telescopes SOFIA cannot fulfill its scientific objectives. Therefore the money would be better invested in other missions. The SOFIA User's Group disputes this rationale, and the German government has stated that it was not consulted in advance of this decision.[8] Furthermore, the decision to cancel SOFIA so early in its operational lifetime implies that NASA never conducted a senior review to evaluate the merits of the science relative to other operational missions or the potential science that could be returned from developing new missions rather than extending operations.

James Webb Space Telescope (JWST) – JSWT 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

[8] Letter of from Dr. Robert D. Gehrz, Chair of the SOFIA Users Group (SUG) to Michael Day, Management and Program Analyst at the NASA Office of Inspector General – Jet Propulsion Laboratory, March 12, 2014.

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.

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. In 2013, NASA announced that Voyager 1, launched in 1977, had crossed the Heliopause, which is the boundary of the Solar System and interstellar space. Voyager 1 is the first human-made object to travel so great a distance in the universe. Also in 2013 NASA launched the Interface Region Imaging Spectograph (IRIS), which explores the atmosphere of the sun. Due to schedule problems with the Magnetospheric MultiScale (MMS) mission, designed to investigate how the Earth and Sun's magnetic fields interact, its launch date of March 2015 could be pushed to a later date.

Aeronautics Research Mission Directorate

Budget Authority ($ in millions)	Actual 2013	Enacted 2014	Request FY15	FY14 Vs FY15	National 2016	2017	2018	2019
Aeronautics	**529.5**	**566.0**	**551.1**		**556.8**	**562.2**	**567.8**	**573.5**
Aviation Safety	77.6		-		-	-	-	-
Airspace Systems	89.8		-		-	-	-	-
Fundamental Aeronautics	167.7		-		-	-	-	-
Aeronautics Test	74.6		-		-	-	-	-
Integrated Systems Research	99.0		-		-	-	-	-
Aeronautics Strategy & Management	21.0		-		-	-	-	-
Airspace Ops and Safety Program	-		131.0		132.7	134.6	135.9	137.3
Advanced Air Vehicles Program	-		213.6		211.4	205.8	203.3	205.3
Integrated Aviation Systems Program	-		127.0		125.8	128.0	133.4	134.8
Transformative Aeronautics Concepts Program			79.5		86.8	93.8	95.2	96.2

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 FY15 budget request for ARMD is $551.1 million, a 2.6 percent decrease from the $566 million included in the FY14 appropriations act.

This past year, NASA introduced a new strategic vision for Aeronautics research focused around six strategic thrusts: 1) Safe, efficient growth in global operations; 2) Innovation in commercial supersonic aircraft; 3) Ultra-efficient commercial vehicles; 4) Transition to low-carbon

propulsion; 5) Real-time system-wide safety assurance; and 6) Assured autonomy for aviation transformation.

For FY15, as part of NASA's new strategic vision for Aeronautics research, ARMD has been reorganized from six research programs into four programs: three "mission" programs—the Airspace Operations and Safety Program, the Advanced Air Vehicle Program, and the Integrated Aviation Systems Program—and one program focused on developing high-risk, forward thinking ideas—the Transformative Aeronautics Concepts Program.

The Airspace Operations and Safety Program will develop and explore concepts, algorithms, and technologies to increase throughput and efficiency of the National Airspace System safely. The program will continue the research of the Airspace Systems Program and the aircraft state awareness research and system wide safety research previously conducted by the Aviation Safety Program.

The Advanced Air Vehicles Program will conduct fundamental research to improve aircraft performance and minimize environmental impact from subsonic air vehicles, while also conducting work on rotorcraft, low boom supersonic aircraft, and composite structure for aviation. The program will continue much of the work in the Fundamental Aeronautics Program (while refocusing the research to directly relate to the newly defined strategic thrusts), as well as the Advanced Composites Program that was in the Integrated Systems Research Program and the ground test portion of the Aeronautics Test Program;

The Integrated Aviation Systems Program will conduct work on promising concepts and technologies at the integrated systems level, while also supporting flight research needs across the ARMD strategic thrusts. The program will continue the Environmentally Responsible Aviation and Unmanned Aerial Systems (UAS) in the National Airspace System (NAS) projects, and will include the flight test portion of the Aeronautics Test Program.

The Transformative Aeronautics Concept will focus on infusing internally and externally originated concepts into the six strategic thrusts to create innovation for the aviation system.

Among the goals highlighted in the request is the development, transfer, and implementation of new technologies as part of the Next Generation air traffic control modernization. Another main focus across ARMD programs is the integration of Unmanned Aviation Systems (UAS) into the National Airspace System (NAS). NASA's work on this issue will assist in reducing technical barriers to safety and operational challenges associated with enabling routine civil UAS access to the NAS.

Space Technology

Budget Authority ($ in millions)	Actual 2013	Enacted 2014	Request FY15	FY14 Vs FY15	Notional 2016	2017	2018	2019
Space Technology	**614.5**	**576.0**	**705.5**	**129.5**	**712.6**	**719.7**	**726.9**	**734.2**
Partnerships Dev & Strategic Integration	28.8		33.8		33.7	33.7	33.9	33.9
SBIR & STTR	165.4		190.7		200.9	212.1	212.1	212.1
Crosscutting Space Tech Dev.	247.3		256.6		190.1	185.9	198.5	203.5
Exploration Tech Dev.	173.0		224.5		287.9	288.0	282.4	284.7

The Space Technology Mission Directorate is broken into four main programs; Partnerships Development and Strategic Integration, Small Business Innovative Research (SBIR) & Small Business Technology Transfer (STTR), Crosscutting Space Technology Development, and Exploration Technology Development. NASA requested $705.5 million this year for Space Technology which is an increase of $129.5 million (22 percent) relative to the FY13 enacted funding.

Partnerships Development & Strategic Integration- 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.

This year the OCT will be responsible for "utilizing open innovation approaches and public-private partnerships" to answer the Administration's Asteroid Grand Challenge to "find all asteroid threats to human populations and know what to do about them."

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 2.9 percent of agency research and development dollars relative to extramural agency research and development through these two programs.

Crosscutting Space Technology Development- This program manages development of innovation from early stage investigations through mature, ready-to-implement technologies. Specifically, the technologies targeted in this program have applications in multiple missions throughout NASA and can address needs outside of the agency.

Exploration Technology Development (ETD)- The ETD program provides enabling technologies as well as long-term transformative technologies for future human space exploration missions. ETD focuses "on the highest priority human spaceflight technology gaps as identified by the National Academies."

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

Budget Authority ($ in millions)	Actual 2013	Enacted 2014	Request FY15	FY14 Vs FY15	Notional 2016	2017	2018	2019
Education	**116.3**	**116.6**	**88.9**	**(27.7)**	**89.8**	**90.7**	**91.6**	**92.6**
Aerospace Rsch & Career Dev	54.0	58.0	33.0	(25.0)	33.0	33.0	33.0	33.0
STEM Education & Accountability	62.3	58.6	55.9	(2.7)	56.8	57.7	58.6	59.6

The President's FY15 request for NASA's Education program is $88.9 million, a $27.7 million decrease from the FY14 enacted levels. The FY15 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. The request includes the proposed consolidation of 11 STEM education programs in order to internally restructure and better integrate NASA's STEM education initiatives. NASA's STEM education activities will be unified under the Office of Education. However, an additional $15 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 program at $6 million per year. NASA has proposed to internally consolidate some education functions, assets, and efforts previously funded in the Human Exploration and Operations Mission Directorate, Aeronautics Research Mission Directorate, and Cross Agency Support Accounts.

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 FY14. 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 FY14.

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 Project. 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.

Cross Agency Support (CAS)

	Actual	Enacted	Request	FY14 Vs	Notional			
Budget Authority ($ in millions)	2013	2014	FY15	FY15	2016	2017	2018	2019
Cross Agency Support	2,711.0	2,793.0	2,778.6	(14.4)	2,806.4	2,834.4	2,862.8	2,891.4
Center Management & Ops	1,991.6	-	2,038.8		2,059.2	2,079.7	2,100.5	2,121.6
Agency Management & Ops	719.4	-	739.8		747.2	754.7	762.3	769.8

CAS activities manage the administration of the agency, operate and maintain 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 $2.778 billion for CAS in FY15, a decrease of .5 percent.

Construction & Environmental Compliance and Restoration (CECR)

	Actual	Enacted	Request	FY14 Vs	Notional			
Budget Authority ($ in millions)	2013	2014	FY15	FY15	2016	2017	2018	2019
Construction & Environmental Compliance & Restoration	646.5	515.0	446.1	(68.9)	1,066.0	382.7	386.6	390.4
Construction of Facilities	589.5		370.6		302.7	305.7	308.8	311.8
Environmental Compliance and Restoration	57.0		75.5		763.3	77.0	77.8	78.6

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 FY15 cuts the CECR account by over 13 percent. After taking into account an increase of $18 million for environmental compliance, the construction account is actually cut 37 percent. This appears to be largely a result of deferring or cancelling the $93.7 million investment in Measurement Science Laboratory (MSL) at the Langley Research Center (LaRC) that was scheduled to begin construction in FY15 and operations in FY18.

Inspector General

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 million in FY15, which represents a 1.3 percent reduction from previous year funding.

Chairman PALAZZO. The Subcommittee on Space will come to order.

Good morning. Welcome to today's hearing titled "A Review of the National Aeronautics and Space Administration Budget for Fiscal Year 2015."

In front of you are packets containing the written testimony, biography and Truth in Testimony disclosure for today's witness. I recognize myself for five minutes for an opening statement.

Mr. Administrator, I will begin my statement this morning with a sincere thank you for your leadership and the hard work of all the men and women at NASA. While I do not always agree with the Administration's decisions, I appreciate the good people at NASA and their service to the country.

The President's budget request this year for NASA is $17.4 billion, a decrease of $186 million relative to the Consolidated Appropriations Act, which was signed by the President only two months ago. I am most concerned by the Administration's insistence on reordering the funding priorities of the agency. The Consolidated Appropriations Act provided clear priorities to the Administration. In fact, Administrator Bolden heaped praise on the appropriation for NASA the day it passed, and yet we see again that the President has chosen to realign those priorities he agreed to in both the NASA Authorization Act of 2010 and the Consolidated Appropriations Act.

Again this year, the Administration is proposing funding for the Asteroid Redirect Mission, or ARM. There is still no budget profile, program office or schedule for this mission, so we are in the same position we were a year ago when it was first announced. The Consolidated Appropriations Act directed NASA to produce more information on this mission before further investments will be considered. I hope to hear from the Administrator today that these plans are under development and that the agency is also taking ongoing concerns from many in the scientific community and its own advisory groups into consideration.

At the same time the Administration has requested these additional funds for the ARM, cuts have been made to top agency and Congressional priorities. For the fourth year in a row, the Administration has requested a reduction to the Orion crew capsule and the Space Launch System. This year's budget request cuts these programs by $330 million. As Administrator Bolden stated the day the appropriations bill passed, the bill keeps NASA's deep space exploration program on track. Surely if $1.6 billion would only keep the SLS and Orion on track, a $219 million cut could derail those efforts. This is simply unacceptable. These critical assets are the essential components of our future deep space human exploration efforts. The Administration cannot in the same breath claim to support space exploration while continuing to divert agency budgets in a manner that undermines that mission.

The agency must be mission-focused and budget-vigilant, and that is why I will continue to work for appropriate funding levels for these systems. Just as in years past, the Administration is requesting large increases in the Commercial Crew program without any data to back up their request.

One of my top priorities as Chairman of this Subcommittee, especially in times of international uncertainty, is ensuring we restore the capability to launch American astronauts on American rockets from American soil as soon as possible. Our commercial partners are the key to making that possible as they relieve us from relying on the Russians for access to the International Space Station.

But in times of budget constraint, we must be sure we are doing the best we can with what we have. This proposal should be accompanied by a strategic acquisition plan and other planning documents in order to justify the Administration's budget request increase of $152 million.

Additionally, this year's budget request also includes the cancellation of the SOFIA program. American taxpayers invested $1.2 billion on this one-of-a-kind asset, and the Administration is proposing cancellation just as it gets off the ground.

Administrator Bolden, Dr. Holdren said you might be more helpful in answering questions we have about the proposed cancellation of SOFIA. I would hate to see us cancel yet another international partnership in the same manner as we did with the ExoMars project. I am moved to ask, how can the international community rely on this Administration to collaborate on anything without fear of cancellation?

There is no doubt that our Nation's space program is facing many challenges. That is all the more reason the Administration must deliver budgets and goals that support a serious commitment to human exploration and stop using the Science Mission Directorate as a partisan football. The scientists and engineers who work every day to maintain U.S. leadership in space are counting on you. The American public is counting on the President and they are counting on each of us here in this room to have an honest conversation about where we are at this time in our Nation's space program and to make tough choices. It means setting politics aside and investing strategically in our future.

I am ready to work together to ensure the priorities from previous legislation that the President signed will be honored. The future of our space program depends on it.

[The prepared statement of Mr. Palazzo follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON SPACE
CHAIRMAN STEVEN M. PALAZZO

I recognize myself for five minutes for an opening statement. Mr. Administrator, I will begin my statement this morning with a sincere thank you for your leadership and the hard work of all the men and women at NASA. While I do not always agree with the Administration's decisions, I appreciate the good people at NASA and their service to the country.

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This year's budget request cuts these programs by $330 million. As Administrator Bolden stated the day the Appropriations bill passed, "The bill keeps NASA's deep space exploration program (the Space Launch System and Orion) on track." Surely if $1.6 billion would only keep the SLS and Orion on track, a $219 million cut could derail those efforts.

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But, in times of budget constraint, we must be sure we are doing the best we can with what we have. This proposal should be accompanied by a strategic acquisition plan and other planning documents in order to justify the Administration's budget request increase of $152.3 million.

Additionally, this year's budget request also includes the cancellation of the SOFIA program. American taxpayers invested $1.2 billion on this one of a kind asset, and the Administration is proposing cancellation just as it gets off the ground. Administrator Bolden, he said you might be more helpful in answering questions we have about the proposed cancellation of SOFIA.

I would hate to see us cancel yet another international partnership, in the same manner as we did with the ExoMars project. I am moved to ask, how can the international community rely on this Administration to collaborate on anything without fear of cancellation?

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The American public is counting on the President. They are counting on each of us here in this room to have honest conversation about where we are at this time in our nation's space program, and to make tough choices. It means setting politics aside and investing strategically in our future. I am ready to work together to ensure the priorities from previous legislation - that the President signed—will be honored. The future of our space program depends on it.

Chairman PALAZZO. I now recognize the Ranking Member, the gentlewoman from Maryland, Ms. Edwards.

Ms. EDWARDS. Thank you very much, Mr. Chairman, and thank you also to General Bolden for being here today with us.

I appreciate holding a hearing to review the National Aeronautics and Space Administration's budget for Fiscal Year 2015, and I want to welcome of course Administrator Bolden. I also congratulate NASA and all of its contractor private sector workforce on a number of successful launches and milestones that they have achieved over this past year.

I am and always have been and will be a passionate person about NASA and our space program and the people who work in it. Our program, our space program has been a symbol of our greatness as a Nation, a means for peaceful collaboration with other Nations, a bedrock of our capacity for innovation, and a powerful source of inspiration for student and professional engagement in science and technology. NASA will continue to be these things and more, but only if we provide it with the stability and resources needed to meet its multi-mission responsibilities in aeronautics, space science, Earth Science, human spaceflight, and human exploration.

That is why I am pleased that the $18.3 billion proposed for NASA for Fiscal Year 2015, which incorporates the funding being requested as part of the Opportunity, Growth, and Security Initiative, is close to the level specified for Fiscal Year 2015 in the NASA Authorization Act, the bill that I and full Committee Ranking Member Johnson introduced last July. I support the President's Growth Initiative to make further investments in research and development that will help grow the Nation's economy and create jobs.

That said, I recognize that there will be much discussion about this initiative, so we need to understand the impacts to NASA's programs if the agency is only provided the base-level request of $17.46 billion. For example, I have questions about the reduced funding requested for the Space Launch System and Orion crew vehicle, and the potential impact it will have on the programs' abilities to achieve critical test flights in 2017 and 2021.

I also want to understand the implications of the proposed shutdown of the Stratospheric Observatory for Infrared Astronomy—SOFIA—good thing we call it SOFIA—a project that was undertaken in partnership with Germany, and I want to hear about whether there are options that should be explored and that were explored that might preserve our investment in this facility. I also want to learn more about the proposal to fund studies on a potential Wide-Field Infrared Survey Telescope—WFIRST—mission, and the science that such a mission might enable.

I look forward to hearing from Administrator Bolden about increases being requested for the Commercial Crew program. We need to know what we will be getting for that money, and how NASA will ensure that both astronaut safety and the interests of the taxpayer will be protected.

In addition, I hope to learn today whether the base-level request for the International Space Station, and particularly that for research on the ISS, will be sufficient to ensure that a robust re-

search pipeline is in place to support the proposed extension of ISS operations and utilization through 2024, and I have questions about the proposed changes to NASA's education programs. We have raised those questions here in this Committee before. Those programs today played a critical role in inspiring so many of our Nation's youth to seek science and technical degrees and careers.

Mr. Chairman, I also want to take this opportunity to clarify for the record, that while I paid the NASA Administrator a compliment for his passionate and lucid explanation of the Asteroid Redirect Mission to a group of students recently—that is how I spend my time watching television—I continue to have questions about this potential mission and how it would contribute, relative to other potential missions, to enable the goal of sending humans to the surface of Mars.

And finally, Mr. Chairman, I am hopeful that today's discussion will help inform our continuing work on reauthorizing NASA. I want to commend you and your staff, Mr. Chairman, for working with our team because I think that we can get from here together on the same page as Republicans and Democrats in support of our space mission. I know that we both share the goal of achieving a strong, bipartisan NASA Authorization bill to provide the stability and resources NASA needs if it is to accomplish the inspiring missions we have asked it to carry out.

Thank you, and I yield back the balance of my time.

[The prepared statement of Ms. Edwards follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON SPACE
RANKING MINORITY MEMBER DONNA F. EDWARDS

Thank you, Mr. Chairman, for holding today's hearing on "A Review of the National Aeronautics and Space Administration Budget for Fiscal Year 2015." I'd like to welcome back Administrator Bolden and also to congratulate NASA and its contractor workforce on a number of successful launches and milestones achieved over the past year.

I am and always have been passionate about NASA and our space program. Our space program has been a symbol of our greatness as a nation, a means for peaceful collaboration with other nations, a bedrock of our capacity for innovation, and a powerful source of inspiration for student and professional engagement in science and technology.

NASA will continue to be these things and more, but only if we provide it with the stability and resources needed to meet its multimission responsibilities in aeronautics, space science, Earth science, human spaceflight, and human exploration. That is why I'm pleased that the $18.3 billion dollars proposed for NASA for Fiscal Year 2015, which incorporates the funding being requested as part of the Opportunity, Growth, and Security Initiative, is close to the level specified for Fiscal Year 2015 in the NASA Authorization Act bill that I and full Committee Ranking Member Johnson introduced last July. I support the President's Growth Initiative to make further investments in research and development that will help grow the nation's economy and create jobs.

That said, I recognize that there will be much discussion about this Initiative, so we need to understand the impacts to NASA's programs if the agency is only provided the base level request of $17.46 billion. For example, I have questions about the reduced funding requested for the Space Launch System and Orion crew vehicle, and the potential impact it will have on the programs' ability to achieve critical test flights in 2017 and 2021.

I also want to understand the implications of the proposed shutdown of the Stratospheric Observatory for Infrared Astronomy (SOFIA)--a project that was undertaken in partnership with Germany—and hear about whether there are options that should be explored that might preserve our investment in this facility. I also want to learn more about the proposal to fund studies on a potential Wide-Field Infrared

Survey Telescope (WFIRST) mission, and the science that such a mission might enable.

I look forward to hearing from the Administrator about increases being requested for the commercial crew program. We need to know what we will be getting for that money, and how NASA will ensure that both astronaut safety and the interests of the taxpayer will be protected. In addition, I hope to learn today whether the base level request for the ISS, and particularly that for research on the ISS, will be sufficient to ensure that a robust research pipeline is in place to support the proposed extension of ISS operations and utilization through 2024. And I have questions about the proposed changes to NASA's education programs, which have played a critical role in inspiring so many of our nation's youth to seek science and technical degrees and careers.

Mr. Chairman, I also want to take this opportunity to clarify, for the record, that while I paid the NASA Administrator a compliment on his passionate and lucid explanation of the Asteroid Redirect Mission to a group of students recently, I continue to have questions about this potential mission and how it would contribute, relative to other potential missions, to enabling the goal of sending humans to the surface of Mars.

Finally, Mr. Chairman, I am hopeful that today's discussion will help inform our continuing work on reauthorizing NASA. I know that we both share the goal of achieving a strong, bipartisan NASA Authorization bill to provide the stability and resources NASA needs if it is to accomplish the inspiring missions we have asked it to carry out.

Thank you, and I yield back the balance of my time.

Chairman PALAZZO. Thank you, Ms. Edwards. I now recognize the Chairman of the full Committee, the gentleman from Texas, Mr. Smith.

Chairman SMITH. Thank you, Mr. Chairman, and we appreciate Administrator Bolden appearing before us again today to present the President's budget request for NASA. While we may disagree on a few topics, I think we share the same desire to ensure that NASA remains the world's preeminent space agency so that our Nation continues to lead the world in space exploration and discovery, and that is why I am concerned with the President's Fiscal Year 2015 budget request. Just three months ago, Congress and the President reached an agreement on NASA's budget. Now, just a few weeks later, the President recommends a $185 million cut to NASA. It also again seeks to fund an asteroid redirect or retrieval mission despite what one article this week described as "scant support in Congress and similarly muted interest in the science community."

The Administration continues to push this mission on NASA without any connection to a larger exploration roadmap and absent support from the scientific community or NASA's own advisory bodies. It is a mission without a realistic budget, without a destination and without a certain launch date.

The committee has heard a number of concerns about the mission as well as many promising alternatives. For instance, the Committee recently held a hearing on the potential for a flyby mission to Venus and Mars in 2021. While the mission is not without challenges, it is intriguing and would catch the public's imagination.

Unfortunately, the budget underfunds the Space Launch System and Orion programs as well as the Planetary Science Division. The White House's approach has been to raid NASA's budget to fund the Administration's environmental agenda. There are 13 other agencies that are involved in climate change research yet only one conducts space exploration. In the last seven years, the Earth Science Division funding has increased over 63 percent. NASA needs to remember its priorities and the priority is space exploration.

I am glad to see that NASA is working to complete the James Webb Space Telescope and to initiate the production of the Wide-Field Infrared Space Telescope as well. And NASA finally has included a budget line for a Europa mission, even though it is just for one year and too little. Over the last two years, Congress has funded a Europa mission at $75 million and $80 million, so the one-year funding of $15 million is as disappointing as the potential life that may exist under the ice of Jupiter's moon is fascinating.

Our leadership in space has slipped. The Administration, I hope, will step back, look at the agency as a whole and work to put it on a long-term path to achieve worthy and inspirational goals on behalf of our Nation.

Space exploration inspires American students and excites scientists. If we want to continue to be a world leader and take giant leaps for mankind, NASA must ensure its budget reflects the importance of space exploration.

Thank you, Mr. Chairman. I will yield back.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF FULL COMMITTEE CHAIRMAN
LAMAR S. SMITH

Thank you, Mr. Chairman. And we appreciate Administrator Bolden appearing before us once again to present the President's budget request for NASA.

While we may disagree on a few topics, I think we share the same desire to ensure that NASA remains the world's preeminent space agency so that our nation continues to lead the world in space exploration and discovery. That is why I am concerned with the President's Fiscal Year 2015 budget request. Just three months ago, Congress and the President reached an agreement on NASA's budget.

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Thank you, Mr. Chairman, and I yield back.

Chairman PALAZZO. Thank you, Mr. Chairman. I now recognize the Ranking Member, the gentlewoman from Texas, Ms. Johnson.

Ms. JOHNSON. Thank you very much.

Good morning, and welcome to this morning's hearing, Administrator Bolden. I look forward to your testimony today. You have a very challenging job with a great many responsibilities, and I know that all of us appreciate the service you render to our nation.

As the Chairman has indicated, we are here today to review NASA's Fiscal Year 2015 budget request. At the outset, I want to say that I am heartened that the President has been willing to commit more than $18.3 billion to NASA for Fiscal Year 2015, a four percent increase over the Fiscal Year 2014 appropriations. Achieving that level, however, will require Congress to work with the President to achieve targeted spending cuts and increased revenue to provide necessary offsets and stay within the budget agreement. I hope that my friends across the aisle will agree with me that NASA and its programs are worth a little effort on Congress's part to identify the needed funds. The ball is now in our court.

That said, I want to use my remaining time to raise a few issues that I hope will be discussed today. First, I am troubled by the cuts being proposed to NASA's education activities. These cuts do not appear to be just the result of achieving increased efficiencies through interagency collaborations. They are cuts, pure and simple, which I consider to be the wrong message to be sending as we try to engage the next generation in STEM pursuits.

Second, I have to confess that I am a bit weary of the annual cycle of the Administration proposing reductions in the funding for the Space Launch System and the Orion exploration vehicles. Both of those vehicles are under development and approaching initial testing milestones. This is the point in a healthy vehicle development program that funding should be increasing, not decreasing. I expect that this is an area that Congress will once again have to address.

And third, I am a bit puzzled by the cuts proposed for NASA's science programs. Those programs provide not only exceptional science, but also important outreach opportunities and the ability to engage our international partners in meaningful collaborations. We are going to need to look closely at what is being proposed in this budget.

Finally, I want to know more about the proposed increases to NASA's Commercial Crew program. Those increases are quite significant, especially in the context of NASA's constrained budgetary environment. While I certainly want to reduce our dependence on Russia for crew transportation to and from the International Space Station, I am not prepared to provide a blank check to do so.

As you know, Representative Edwards and I expressed deep concern last fall over NASA's intention to prioritize prices over safety in its evaluation of vendor proposals leading to upcoming contract awards for development and certification of commercial crew systems. Unfortunately, NASA chose not to make any changes in its final solicitation before it went out. The agency's action is directly counter to the recommendations of the Columbia Accident Investigation Board, and despite Administrator Bolden's undisputed personal commitment to safety, I think that is a very worrisome step

for the agency to take. Moreover, NASA is waiving the requirement for certified cost or pricing data as part of that same contract, data that has traditionally been required to protect both the agency and the taxpayer.

Administrator Bolden, NASA still has significant time to correct both of these deficiencies before bidders submit their final updates to their proposals later this spring. I urge you to do so, as I would find it difficult to support the funding you are requesting for commercial crew in the absence of such safeguards.

Well, we have a lot to talk about today, and I again want to welcome you to today's hearing, Administrator Bolden, and I yield back the balance of my time. Thank you.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF FULL COMMITTEEE
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Well, we have a lot to discuss today. I again want to welcome you to today's hearing, Administrator Bolden, and I yield back the balance of my time.

Chairman PALAZZO. Thank you, Ms. Johnson.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

And at this time I would like to introduce our witness. The Honorable Charles F. Bolden, Jr., is the Administrator of the National Aeronautics and Space Administration. His 34-year career with the Marine Corps included 14 years as a member of NASA's Astronaut Office. After joining the Office in 1980, he traveled to orbit four times aboard the Space Shuttle between 1986 and 1994, commanding two of those missions. Prior to General Bolden's nomination as NASA Administrator, he was employed as the Chief Executive Officer of JackandPanther LLC, a small business enterprise providing leadership, military and aerospace consulting and motivational speaking.

As our witness should know, spoken testimony is limited to five minutes after which the Members of the Committee will have five minutes each to ask questions.

I now recognize General Bolden for his testimony.

TESTIMONY OF HON. CHARLES F. BOLDEN, JR., ADMINISTRATOR OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

General BOLDEN. Thank you very much, Mr. Chairman.

Members of the Subcommittee, thank you all for this opportunity to discuss NASA's Fiscal Year 2015 budget request. A more detailed written summary of the request has already been made available to the Subcommittee so my verbal testimony will just touch on the highlights.

The $17.5 billion budget request affirms the bipartisan Strategic Exploration Plan agreed to with Congress in 2010 and it ensures that the United States will remain the world's leader in space exploration and scientific discovery for years to come. It is an investment right here on Earth for the benefit of the American people and the entire global economy. I have a chart I would like to put up, Mr. Chairman, if I may, for the rest of my statement, and I will refer to this chart off and on as we go.

[Chart.]

This budget keeps NASA on the steady path we have been following, a steppingstone approach to meet the President's challenge of sending humans to Mars in the 2030s, and as you always see on a chart, you go from left to right, where we are today to where we want to be in the 2030s.

The International Space Station remains our springboard to the exploration of deep space and Mars. We guarantee we will have this unique orbiting outpost for at least another decade with our commitment to extend it until at least 2024. This means an expanded market for private space companies, more groundbreaking research and science discovery in microgravity, and opportunities to live, work and learn in space over longer periods of time. Astronauts aboard the ISS are helping us learn how to safely execute extended missions deeper into space. Later this year, we will see Exploration Flight Test, or EFT–1, of Orion. NASA is pressing forward with development of the Space Launch System and Orion,

preparing for an uncrewed mission of the two together in Fiscal Year 2018.

The budget also supports the Administration's commitment that NASA be a catalyst for the growth of a vibrant American commercial space industry. Already, two companies, SpaceX and Orbital Sciences, are making regular cargo deliveries to the Space Station. Later this year, we will move beyond commercial cargo and award contracts to American companies to send astronauts to the station from American soil and end our sole reliance on Russia. If Congress fully funds our Fiscal Year 2015 request, I believe we can do this by the end of 2017.

Unfortunately, due to the reduced funding the past few years for the President's Launch from America plan, NASA may need to extend our current contract with the Russians and purchase more seats on the Soyuz spacecraft. Instead of investing $450 million into the U.S. economy to support American jobs, we could be spending that money in Russia. Budgets are about choices. The choice here is between fully funding the request to bring space launches back to American soil or continuing to send money, millions, to the Russians. It is that simple. The Obama Administration chooses to invest in America, and we are hopeful that Congress will do the same.

In addition to continuing ISS research, strengthening partnerships with commercial and international partners, and building the next-generation heavy lift rocket and crew capsule to take our astronauts farther into space than ever before, our steppingstone approach includes a plan to robotically capture a small near-Earth asteroid and redirect it safely to a stable orbit in the Earth-Moon system where astronauts can visit and explore it. Our Asteroid Redirect Mission will help us develop technologies including solar electric propulsion needed for future deep space missions to Mars. Under our asteroid initiative, we enhance detection and characterization of near-Earth objects and improve understanding of asteroid threats to the planet.

NASA's Fiscal Year 2015 budget request continues support for science missions heading toward destinations such as Jupiter and Pluto. It enables NASA to continue making critical observations of Earth and developing applications to directly benefit our Nation and the world. It maintains steady progress on the James Webb Space Telescope toward its 2018 launch. Our aeronautics program will continue to focus on substantially reducing fuel consumption, emission and noise to help make the Next Generation Air Transportation System, or NextGen, a reality.

Finally, all of NASA's investments help drive technology and innovation, spur economic activity and create jobs. That is why the President's Opportunity, Growth, and Security Initiative with Congressional approval will provide NASA nearly $900 million in additional funding in Fiscal Year 2015 to focus on specific areas where we can advance our priorities.

The Fiscal Year 2015 budget advances NASA's strategic plan for the future. We will continue to build U.S. preeminence in science and technology, improve life on Earth, and protect our home planet while creating good jobs and strengthening the American economy.

Thank you, Mr. Chairman. I will be happy to respond to any questions you or other Members of the Subcommittee may have.

[The prepared statement of General Bolden follows:]

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UNTIL PRESENTED
BY WITNESS
March 27, 2014

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

before the

Subcommittee on Space
Committee on Science, Space and Technology
U. S. House of Representatives

Mr. Chairman and Members of the Subcommittee, I am pleased to have this opportunity to discuss NASA's FY 2015 budget request. The requested budget of $17.46 billion provides the resources NASA needs to pursue the goals and priorities that the Congress and the Administration have established for the Agency and will ensure that NASA will remain the world's leader in space. A summary of the FY 2015 budget request is appended to this statement.

The President's FY 2015 request supports NASA's continuing quest to extend human presence into deep space and on to Mars. NASA will continue to perform research aboard the International Space Station (ISS), partner with American industry for crew and cargo delivery to low Earth orbit (LEO), develop the Space Launch System (SLS) and Orion crew vehicle, and test our new capabilities in the proving ground of cis-lunar space before sending a human mission to the Red Planet. NASA will also continue to develop a rich array of commercial and international partnerships as part of its overall exploration framework. As we speak, American astronauts aboard the ISS are learning the fundamental lessons necessary to safely execute extended missions deeper into space. Later this year we will see the Exploration Flight Test-1 (EFT-1) of Orion atop a Delta IV Heavy launch vehicle. NASA is pressing forward with development of SLS and Orion, preparing for a first, uncrewed mission in FY 2018.

As a critical element in this long-term exploration strategy, as well as a source of continuing scientific and material benefits to life on Earth, operations in LEO remain among NASA's highest priorities. With the Administration's commitment to the extension of ISS operations through 2024, NASA looks forward to expanded research opportunities with continuing support from our commercial partners for both crew and cargo. Two American companies are launching supplies to the ISS from U.S. soil. NASA will complete a commercial crew competition this summer, and if Congress fully funds our FY 2015 budget request, we believe we can stay on track to launch astronauts to the ISS from American soil by the end of 2017. This capability is critically important to safe/sustained operations, and will end our sole reliance on our Russian partners for this service. The requested funding is required to meet this critical near-term need.

Consistent with the 2010 NASA Authorization Act (P.L. 111-267) and the National Space Policy, NASA continues to make solid progress on the development of SLS and Orion for a series of test flights including a compelling mission in the proving ground of cis-lunar space to redirect a small asteroid into orbit around the Moon, and to send U.S. astronauts to rendezvous with and explore this target. The proving ground of cis-lunar space also puts the Nation in a position from which

we may help our commercial and international partners robotically explore other destinations on that pathway, such as the Moon.

The Asteroid Redirect Mission (ARM) will enable NASA to test powerful Solar Electric Propulsion (SEP) and integrated human/robotic vehicle operations in deep-space trajectories. Like the invaluable ISS, this mission will provide NASA with critical knowledge, experience and technologies for future human exploration missions deeper into space. Drawing on our long-term investments across three Mission Directorates, the FY 2015 request supports continued core capability development and formulation of the integrated mission concept. The overall asteroid initiative also includes enhanced Near Earth Object (NEO) detection and characterization, which will extend our understanding of the NEO threat while providing additional opportunities for investigations of asteroids and demonstrations of technologies and capabilities.

NASA's FY 2015 request for Science supports operation of the world's premier constellation of spacecraft dedicated to exploring Earth, the solar system, and the universe beyond, while we continue to develop the next generation of missions in pursuit of our Nation's highest priority space and Earth science. The James Webb Space Telescope (JWST), NASA's next-generation successor to the Hubble Space Telescope (HST), continues on schedule for its 2018 launch. In recent months, NASA has completed rigorous testing of the spine of the massive telescope and completed the primary mirrors for integration. As we announced last year, we have begun work on a large Curiosity-scale rover for a 2020 mission to Mars, and the FY 2015 request includes funding to continue pre-formulation activities of a potential mission to Europa, one of Jupiter's moons believed to harbor a vast subsurface ocean. NASA will launch five Earth science missions in calendar year 2014, taking advantage of the unique vantage point of space to secure new insights into our home planet. The Earth science budget will support airborne campaigns to the poles and hurricanes, development of advanced sensor technologies, and use of satellite observations and data analysis tools to improve natural hazard and climate change preparedness.

With NASA's FY 2015 request, our pioneering Aeronautics research program will continue to focus on substantially reducing aircraft fuel consumption, emissions, and noise – and help make the Next Generation Air Transportation System, or NextGen, a reality. NASA's Aeronautics Research Mission Directorate (ARMD) will continue to implement the strategic vision for aeronautics that NASA launched last year, with a focus on addressing the challenges facing the U.S. aviation community – civil and military – in the coming decades.

In essential support of the Agency's broader mission, the FY 2015 request supports an active Space Technology Program to advance cutting-edge technologies, providing an on-ramp for new space technologies, creating a pipeline that matures them from early-stage through flight, and delivering innovative solutions that dramatically improve technology capabilities for NASA, the aerospace sector, and the Nation. The request supports the sustained investments that NASA must make to mature the capabilities we need to achieve the challenging goals that the Congress has set for us. By the end of FY 2014, NASA will test and deliver two candidate designs for high-power solar electric systems for SEP with critical applications for deep-space exploration as well as for Earth-orbital activities. By the end of calendar year 2015, NASA will have completed seven Space Technology missions in 24 months, including demonstration of a deep-space atomic clock for advanced navigation, the green propellant demonstration (an alternative to highly toxic hydrazine), a solar sail to demonstrate propellant-free propulsion, and four small spacecraft missions pioneering new technologies. The Space Technology Program is also developing high performance systems for decelerating spacecraft at Mars, high bandwidth laser communications with the potential to transform communication systems for both space exploration and

commercial use, advanced life support technology, advanced robotics, and lightweight composite propellant tanks.

The program laid out in detail in NASA's FY 2015 request continues NASA's implementation of the priorities established for it in the bipartisan NASA Authorization Act of 2010. In the current constrained budget environment, we have designed a balanced program that pursues the Nation's highest priorities in science, exploration, and aeronautics; with a critical technology development program to develop essential capabilities. The FY 2015 request supports the next steps on the way to Mars in a sustainable way. It enables NASA to restore an American capability for sending humans to orbit while continuing development of a deep-space capability for human space flight. This is not an either-or scenario. Each is critically dependent on the other. The request supports the Nation's highest priority science and technology goals for space. NASA appreciates the strong budget support the Agency has received despite a difficult budget environment, and we are fully committed to delivering the world's leading space program on behalf of the American people.

NASA is pleased to be included in the President's Opportunity, Growth, and Security Initiative (OGSI). Under this initiative, NASA would receive nearly $885.5 million in additional funding in FY 2015 to focus on specific priorities. This initiative recognizes NASA as a critical source of innovation and technology that creates opportunity, economic growth, and ultimately security and prosperity. NASA's funding under OGSI would focus on priority investment opportunities such as an expanded Space Technology Program, reducing risk and enhancing competition in the Commercial Crew Program, continuing currently operating science missions and accelerating work on potential future missions. NASA's portion of OGSI would also enable further development work on SLS and Orion, more fully utilize the ISS, and support additional Earth Science mission development, advanced computational fluid dynamics research and increased investment in composite materials.

Science

With 95 missions in development and actively observing Earth, the Sun, the planets, and the universe beyond, NASA remains the world's premier space science organization and the critical source of information on the home planet. The President's FY 2015 budget request for the Science program includes $4,972.0 million, with $1,770.3 million for Earth Science, $1,280.3 million for Planetary Science, $607.3 million for Astrophysics, $645.4 million for the James Webb Telescope, and $668.9 million for Heliophysics.

Earth Science

The President's FY 2015 budget request enables NASA to continue to make critical spaceborne measurements of Earth, our home; to conduct and fund a comprehensive, competed scientific research program to turn those measurements into an understanding of our complex planet; and to use the measurements and understanding to develop and demonstrate applications that will provide direct benefit to our Nation, and indeed all of humanity. Today, there are 17 NASA-developed research satellites on orbit, making measurements of more than 60 key aspects of our planet's environment. Just a few weeks ago, in collaboration with the Japan Aerospace Exploration Agency (JAXA), the Global Precipitation Measurement mission (GPM) was launched to provide the first-ever, accurate, global maps of rain- and snowfall over the globe. During the rest of 2014, NASA will be launching four more Earth observing research missions: Orbiting Carbon Observatory-2 (OCO-2) to measure global carbon dioxide concentrations with unprecedented coverage and accuracy; RapidScat to the ISS, to make measurements of ocean wind speed and direction; Cloud-Aerosol Transport System (CATS), also to the Space Station, to measure atmospheric aerosols; and, in November, the Soil Moisture/Active Passive (SMAP)

mission to make accurate measurements of soil moisture and freeze-thaw cycling. These 2014 missions will be followed in 2015-2017 by the SAGE-III (Stratospheric Aerosol and Gas Experiment III) instrument to the ISS for atmospheric trace gas profile data, including ozone measurements; the Gravity Recovery and Climate Experiment (GRACE)-Follow On gravity mission with our German partners to measure changes in the Earth's gravity field and water storage, such as aquifer level changes; a constellation of eight smallsats, called Cyclone Global Navigation Satellite System (CYGNSS), to use reflected Global Positioning System (GPS) signals to measure conditions in cyclones and hurricanes; an instrument called Tropospheric Emissions: Monitoring of Pollution (TEMPO) to fly on a commercial geostationary communications satellite, to measure air quality over greater North America; and Ice, Cloud, and land Elevation Satellite-2 (ICESAT-2), to make precise measurements of our planet's rapidly changing ice caps and glaciers.

NASA is now developing the Pre-Aerosol, Clouds and ocean Ecosystem (PACE) ocean color and aerosol continuity mission, and the NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NI-SAR) mission in collaboration with the Indian space agency to measure solid earth processes, ice flows, global vegetation, and response to disasters and geohazards. The FY 2015 budget request also supports NASA to develop missions that will continue key climate data series, including a set of solar irradiance, ozone profile, and Earth radiation budget instruments, and follow-on capabilities in support of U.S. Geological Survey for sustained land imaging following our successful launch of Landsat-8 just one year ago.

Astrophysics and James Webb Space Telescope

NASA is making strong progress on JWST, the most powerful space telescope in history, and remains on cost and schedule for launch in 2018. The Webb telescope is the next in a series of astrophysics missions, including the venerable, yet still unrivaled, HST and the incredibly productive Kepler exoplanet mission, which are revolutionizing our understanding of the universe. After launching in 2018, the Webb telescope will travel one million miles from Earth, unfold its sunshield to the size of a tennis court, and keep its instruments cooled to a temperature of 370-387 degrees below zero Fahrenheit (40-50 Kelvin). The Webb telescope will allow us to observe objects even fainter than HST can see, which will allow us to study every phase in the history of our universe, ranging from the first luminous glow after the Big Bang, to the formation of solar systems capable of supporting life on planets like Earth, to the evolution of our own solar system. The FY 2015 request will support work to continue testing the integrated science instrument module for JWST, continue the construction of the spacecraft that will carry the science instruments and the telescope, and begin the assembly of the delivered mirror segments into the telescope backplane.

NASA's Astrophysics Program operating missions include the Hubble, Chandra, Spitzer, and Kepler telescopes; and other missions that together comprise an unrivaled, and in many ways unprecedented resource for the study of our universe. NASA is currently working with our German partner to identify a path forward for the Stratospheric Observatory for Infrared Astronomy (SOFIA), a mission with high annual operating costs that cannot be accommodated within the FY 2015 budget request. In FY 2015, NASA's next two astrophysics Explorer missions will continue their development. The Neutron Star Interior Composition Explorer (NICER) will probe the interiors of neutron stars and determine the laws of physics that govern atomic nuclei. NICER will be launched to the ISS in 2016. The Transiting Exoplanet Survey Satellite (TESS) will extend the pioneering work of the Kepler Space Telescope, which showed us that virtually every star in the sky has a planetary system. TESS launches in 2017 and will discover rocky exoplanets orbiting the nearest and brightest stars in the sky in time for the JWST to conduct follow-up observations that will characterize their atmospheres and other properties.

Planetary Science

Planetary science missions continue to explore the solar system in unrivaled scope and depth. This past November, the Lunar Atmosphere and Dust Environment Explorer (LADEE) was successfully lowered into its optimal position in lunar orbit to enable science data collection. Using its ion engines, the Dawn spacecraft is nearing its next target, Ceres, the largest asteroid in the asteroid belt, with an expected arrival in April 2015. Other upcoming outer planet encounters include the New Horizons mission flyby of Pluto in July 2015 and the Juno mission orbit insertion around Jupiter in August 2016. The FY 2015 budget request also includes funding for continuing pre-formulation activities and studies for a potential mission to Jupiter's icy moon, Europa; with compelling evidence of a liquid water ocean beneath its crust, exploration of Europa is vital to our understanding of the habitability of other planets.

Building on the success of NASA's Curiosity rover on Mars, the FY 2015 request supports plans for a robust multi-year Mars program. In a little more than a year on the Red Planet, Curiosity has landed in an ancient river bed, determined the age of the surrounding Martian rocks, found evidence the planet could have sustained microbial life, taken the first readings of radiation on the surface, and shown how natural erosion could be used to reveal the building blocks of life protected just under the surface. Curiosity is providing vital insight about Mars' past and current environments that will aid plans for future robotic and human missions. The current Mars portfolio includes the Curiosity and Opportunity rovers, the Mars Reconnaissance Orbiter, the Mars Odyssey orbiter, and our collaboration on the European Space Agency's Mars Express orbiter. It also includes the new Mars Atmosphere and Volatile EvolutioN (MAVEN) orbiter, launched in 2013 to study the Martian upper atmosphere, which will arrive at the Red Planet in mid-September 2014. Future missions include the 2016 Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission, which will take the first look into the deep interior of Mars; participation in the European Space Agency's 2016 and 2018 ExoMars missions; and the new Mars rover planned for launch in 2020.

The FY 2015 budget request includes enhanced funding for NASA's Near Earth Object survey and characterization activities in support of the ARM effort, as well as to protect our planet. Just last year, the Wide-field Infrared Survey Explorer spacecraft was reactivated, renamed NEOWISE and given a renewed mission to assist NASA's efforts to identify the population of potentially hazardous near-Earth objects (NEOs). NEOWISE's first discovery of its renewed mission came on December 29, 2013 – a large near-Earth asteroid designated 2013 YP139, which was about 27 million miles from Earth with an estimated diameter of roughly 0.4 miles. NEOWISE can also assist in characterizing previously detected asteroids that could be considered potential targets for future exploration missions.

Heliophysics

NASA's Heliophysics Program is composed of 29 spacecraft and the associated research to understand the universal physical phenomena of magnetized plasmas and their interactions. These include the influence of the Sun in our local region of the galaxy, the origins of solar variability, and the coupling among various regions at the Earth and other planetary systems. Last year, NASA successfully launched the Interface Region Imaging Spectrograph (IRIS), a Small Explorer mission. Within a few months, IRIS provided a new understanding of how the outer solar atmosphere is heated to over a million degrees. The FY 2015 budget request will support completion of development of the Magnetospheric Multiscale (MMS) mission, which will launch in 2015 to investigate how magnetic fields connect and disconnect, often releasing tremendous amounts of energy in the process. NASA will continue to develop the Solar Probe Plus (SPP) mission for a planned launch in FY 2018, together with our instrument

contributions to the European Space Agency's Solar Orbiter mission; Solar Probe Plus will repeatedly pass through the hot outer atmosphere of the Sun, to within five times the Sun's diameter, which is much closer than any man-made object ever has flown before. Finally, the Explorer missions selected in 2013 to study Earth's outer atmosphere – Ionospheric Connection (ICON) and Global-scale Observations of the Limb and Disk (GOLD) – are in their preliminary design phases for planned launches in 2017.

Aeronautics Research

NASA's Aeronautics research is making air travel cleaner, safer, and more efficient. NASA's FY 2015 budget request provides $551.1 million to fulfill the Agency's strategic research agenda. This innovative research is aimed at transforming the aviation industry through game-changing advances in the safety, capacity, and efficiency of the air transportation system, while minimizing negative impacts on the environment. NASA's FY 2015 research portfolio is aligned with six strategic research thrusts to directly address the growing global demand for mobility, severe challenges to sustainability of energy and the environment, and technology advances in information, communications, and automation technologies. This portfolio includes those activities in our current portfolio deemed to be the most relevant and critical, as well as new activities focused on high-risk, forward thinking ideas to address aviation's big problems. The Agency will clearly define the most compelling technical challenges facing the aviation industry, and retire these challenges in a time frame that is supported by stakeholders and required by NASA's customers. Over the next two years, NASA will continue to develop, demonstrate, and transition to industry and the Federal Aviation Administration new vehicle and airspace management concepts and technologies to help realize the promise of NextGen, as well as provide technical data, analysis and recommendations to support the integration of unmanned aerial systems (UAS) into the National Air Space. We will strengthen our external partnerships through joint flight experiments using alternative aviation fuels and advanced flight deck and vehicle technologies, and through demonstrations of advanced sensors to improve safety and identify emerging faults before damage occurs. By the end of FY 2015, NASA will close out the six-year Environmentally Responsible Aviation project with a series of integrated technology demonstrations to demonstrate the feasibility of a suite of technologies to meet our aggressive environmental goals. Through the alignment of our research portfolio to address the most critical challenges facing the aviation sector, NASA will be best positioned to continue supporting the global competitiveness of the U.S. aviation industry that contributes to a $47 billion positive balance of trade, infuses $1.3 trillion annually into the U.S. economy and supports more than 10 million direct and indirect jobs[1,2]. NASA is truly with you when you fly.

Space Technology

NASA's FY 2015 request includes $705.5 million for Space Technology, to enable our future in space, drawing on talent from the NASA workforce, academia, small businesses, and the broader national space enterprise, by delivering innovative solutions that dramatically lower costs and improve technological capabilities for NASA and the Nation.

By the end of FY 2014, NASA will test and deliver two candidate designs for large deployable solar array systems, power processing units, and advanced thrusters to support a flight demonstration of SEP. In addition to being important to the future of human spaceflight and the ARM effort, high-power SEP can enable orbit transfer capability for satellites, and addresses the

[1] "Global Aerospace Industry Takes Off for the World's Largest Aerospace Trade Exhibition in 2012," July 6, 2012, International Trade Administration.

[2] "The Economic Impact of Civil Aviation on the U.S. Economy," August 2011, FAA, Page 24, Table 5 and Page 27, Table 8.

rapid power demand increases facing today's communications satellites. Having successfully demonstrated a 2.4-meter propellant tank in 2013, NASA will complete testing a 5.5-meter diameter composite tank to enable lower-mass rocket propellant tanks for future systems, including the SLS. By the end of 2015, NASA will have completed seven Space Technology missions in 24 months, including demonstration of a deep-space atomic clock for advanced navigation that has commercial application for improving GPS systems, the green propellant demonstration (a higher-performing, less toxic alternative to hydrazine), a solar sail to demonstrate propellant-free propulsion, and four small spacecraft missions pioneering new technologies. Building on recent successes with its Low Density Supersonic Decelerator, NASA plans to conduct high-speed tests – at an altitude of 170,000 feet – of the largest planetary parachute ever developed to enable precise landing of higher-mass payloads to the surface of other planets, with particular focus on infusing advanced capabilities into the Mars 2020 mission and future human exploration missions.

NASA's Space Technology investments are aligned with NASA's Human Exploration and Operations and Science Programs to reduce technological barriers and mission risk, and to foster affordable missions. The Space Technology Game Changing Development effort is delivering advanced life-support, advanced robotics, and battery technologies for system demonstrations planned by Human Exploration and Operations. For Science, Space Technology is improving navigational accuracy, developing advanced computing and avionics, and developing advanced Entry, Descent, and Landing (EDL) solutions, observatory technology, and optical communication technology to transmit large amounts of science data from deep space. Space Technology is partnering with Human Exploration and Operations and Science on many activities, including demonstration of in-situ resource utilization, optical communications, and advanced measurements on Mars. These precursor activities will pave the way and reduce risk for future Mars exploration.

Exploration and Space Operations

NASA is building the capabilities and knowledge to send humans farther from the home planet then we have ever been before. The FY 2015 budget request for Exploration is $3,976.0 million with $2,784.4 million for Exploration Systems Development, $848.3 million for Commercial Space Flight, and $343.4 million for Exploration Research and Development. Space Operations, including the ISS and Space Flight Support, form a critical component of the Agency's exploration plans by enabling us to develop the knowledge, experience, and technology necessary for safely living and working in space. The FY 2015 request for Space Operations is $3,905.4 million, with $3050.8 for ISS and $854.6 for Space Flight Support (SFS).

Exploration Systems

The FY 2015 request will enable NASA to continue to meet its milestones in the development of the Space Launch System (SLS), a rocket system ultimately capable of bringing an unprecedented 130 metric tons of payload to Earth orbit. The Orion program continues on track for an uncrewed test flight later this year. This test flight, Exploration Flight Test-1 (EFT-1), will see Orion conduct two orbits of Earth and reenter the atmosphere at approximately 85 percent of lunar re-entry speed of a returning deep-space exploration mission. The test will provide valuable data about the spacecraft's systems – most importantly its heat shield and structure. The flight test article for this mission is already in place at the Kennedy Space Center and being readied for this test. The FY 2015 budget request supports progress toward a first uncrewed test of the Orion and the SLS together, known as Exploration Mission-1 (EM-1) in FY 2018, with the first crewed mission of the two vehicles slated for FY 2021-2022. Orion, SLS, and Exploration Ground Systems (EGS) are using the latest in systems and manufacturing technology to develop the safe and sustainable systems this country needs to extend human presence to Mars. Examples include

Orion's use of time-triggered gigabit Ethernet, SLS' use of friction-stir welding on large structures to build the Core Stage, and EGS' replacement of cables from Pad 39B with the latest in fiber optics. In developing the Orion, SLS, and EGS, NASA is building a national capability for the long-term human exploration of space.

International Space Station

The FY 2015 request supports the ISS with its international crew of six orbiting Earth every 90 minutes. The Station is making deep-space exploration possible, as we build on the knowledge and experience we are gaining from the astronauts living, working, and conducting research on the ISS. On January 8, 2014, the Administration announced it is committing the United States to the extension of ISS operations through at least 2024. This will allow NASA to complete many of the research and technology development activities aboard the ISS necessary to enable planned long-duration human missions beyond LEO; extend the broader flow of societal benefits from research on the Station, which has already resulted in a discoveries that could have significant medical and industrial implications; provide NASA and its private-sector partners time to more fully transition to the commercial space industry the transportation of cargo and crew to LEO; instill confidence in the science community that the ISS platform will be available for important, long-term research endeavors; and help cement continuing U.S. leadership in human spaceflight going forward. NASA's plans for the coming year include preparing for an extended duration, year-long human-crewed mission – slated to launch in March 2015 – to explore human adaptation to space; and continuing to utilize the ISS to improve our ability to live and work in space, including conducting technology demonstrations enabling future exploration. The Center for the Advancement of Science in Space (CASIS) continues to manage the National Laboratory research being conducted in the U.S. segment of the ISS by an array of organizations, including commercial researchers interested in taking advantage of this unique, microgravity facility. One company, NanoRacks, uses standardized hardware to provide a microgravity research option for scientists working in venues ranging from grade school to academia to industry. During its first three years of business, NanoRacks sent 91 investigations to ISS, returned 10 to Earth, and deployed one CubeSat – a new area of focus using satellites that measure about four inches on all sides.

Commercial Crew and Cargo

A top priority for NASA and the Nation is to affordably and safely launch American astronauts and their supplies from U.S. soil, ending our sole reliance on foreign providers and bringing that work back home. Under NASA's Commercial Resupply Services (CRS) contracts, Space Exploration Technologies (SpaceX) was awarded 12 cargo flights to the ISS, and Orbital Sciences Corporation (Orbital) was awarded 8 flights. Counting demonstration flights and CRS resupply flights, SpaceX has now completed three cargo missions to the ISS, successfully delivering cargo and returning scientific samples to Earth, with the fourth mission expected to launch in the next few days. Orbital Sciences Corporation has completed their demonstration mission to the ISS and their first contract mission under CRS to deliver crew supplies, research and other cargo onboard the Cygnus spacecraft. NASA continues to work with its commercial partners to develop a U.S. commercial capability for human spaceflight and plans to launch American astronauts from U.S. soil by the end of 2017. 2014 will be a pivotal year for NASA's Commercial Crew Program (CCP) as the Agency intends to award development and certification contract by August/September for the Commercial Crew Transportation Capability (CCtCap) phase that would lead to operational crewed flights to the ISS. Competition is a key to controlling costs over the long term, and NASA's Aerospace Safety Advisory Panel has opined that competition should be maintained until safety confidence is achieved. Through the successful execution of this partnership, we will return to the United States the vital capability to launch astronauts to the ISS from U.S. soil and return them to Earth.

Education
The Administration is proposing increased interagency coordination of Science, Technology, Engineering, and Mathematics (STEM) education investments, aligned with the Five-Year Strategic Plan released last year by the Committee on STEM Education (CoSTEM). The FY 2015 budget request for Education will enhance the impact of the Federal investment in STEM Education through greater interagency coordination and cooperation in support of a cohesive national STEM strategy focused on four priority areas: K-12 instruction, undergraduate education, graduate fellowships, and informal education activities. The Office of Education will continue its intra-agency consolidation of certain educational programs to eliminate duplication of efforts and achieve maximum leverage of resources.

The FY 2015 budget request of $88.9 million consolidates education activities in the Office of Education, including several elements that may be transferred from NASA's mission directorates under a competitive process. The FY 2015 budget request for the Education account includes funding for the National Space Grant College and Fellowship Program, the Experimental Program to Stimulate Competitive Research (EPSCoR), and the Minority University Research and Education Project (MUREP), and STEM Education and Accountability Projects. These education investments link to NASA's research, engineering, and technology missions. Each of these investments provides unique NASA experiences and resources to students and faculty. The budget also provides $15 million to the Science Mission Directorate to competitively fund the best application of NASA Science assets to meet the Nation's STEM education goals.

Conclusion
Mr. Chairman, thank you for the opportunity to appear before you today to provide you with our progress and status over the past year. I would be pleased to respond to any questions you or the other Members of the Subcommittee may have.

National Aeronautics and Space Administration

FY 2015 PRESIDENT'S BUDGET REQUEST SUMMARY

	Fiscal Year						
	Actual	Enacted	Request	Notional			
Budget Authority ($ in millions)	2013	2014	2015	2016	2017	2018	2019
NASA Total	**16,865.2**	**17,646.5**	**17,460.6**	**17,635.3**	**17,811.5**	**17,989.7**	**18,169.7**
Science	**4,781.6**	**5,151.2**	**4,972.0**	**5,021.7**	**5,071.9**	**5,122.6**	**5,173.9**
Earth Science	1,659.2	1,826.0	1,770.3	1,815.5	1,837.6	1,861.9	1,886.3
Planetary Science	1,274.6	1,345.0	1,280.3	1,304.9	1,337.1	1,355.7	1,374.1
Astrophysics	617.0	668.0	607.3	633.7	651.2	696.8	933.0
James Webb Space Telescope	627.6	658.2	645.4	620.0	569.4	534.9	305.0
Heliophysics	603.2	654.0	668.9	647.6	676.6	673.3	675.5
Aeronautics	**529.5**	**566.0**	**551.1**	**556.6**	**562.2**	**567.8**	**573.5**
Space Technology	**614.5**	**576.0**	**705.5**	**712.6**	**719.7**	**726.9**	**734.2**
Exploration	**3,705.5**	**4,113.2**	**3,976.0**	**4,079.9**	**4,049.4**	**4,107.7**	**3,673.4**
Exploration Systems Development	2,883.8	3,115.2	2,784.4	2,863.3	2,905.9	2,982.1	3,106.6
Commercial Spaceflight	525.0	696.0	848.3	872.3	791.7	730.9	172.0
Exploration Research and Development	296.7	302.0	343.4	344.3	351.8	394.7	394.7
Space Operations	**3,724.9**	**3,778.0**	**3,905.4**	**3,951.9**	**4,062.8**	**4,085.6**	**4,601.8**
Space Shuttle	38.8	–	–	–	–	–	–
International Space Station	2,775.9	–	3,050.8	3,126.5	3,266.9	3,290.3	3,818.6
Space and Flight Support	910.2	–	854.6	825.4	795.9	795.3	783.2
Education	**116.3**	**116.6**	**88.9**	**89.8**	**90.7**	**91.6**	**92.6**
Cross Agency Support	**2,711.0**	**2,793.0**	**2,778.6**	**2,806.4**	**2,834.4**	**2,862.8**	**2,891.4**
Center Management and Operations	1,991.6	–	2,038.8	2,059.2	2,079.7	2,100.5	2,121.6
Agency Management and Operations	719.4	–	739.8	747.2	754.7	762.3	769.8
Construction and Environmental Compliance and Restoration	**646.6**	**515.0**	**446.1**	**379.0**	**382.7**	**386.6**	**390.4**
Construction of Facilities	589.5	–	370.6	302.7	305.7	308.8	311.8
Environmental Compliance and Restoration	57.0	–	75.5	76.3	77.0	77.8	78.6
Inspector General	**35.3**	**37.5**	**37.0**	**37.4**	**37.7**	**38.1**	**38.5**
NASA Total	**16,865.2**	**17,646.5**	**17,460.6**	**17,635.3**	**17,811.5**	**17,989.7**	**18,169.7**

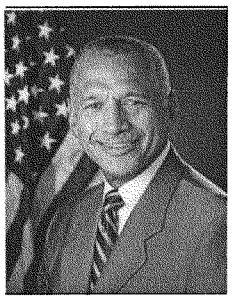
Note: As reflected in the August 2013 Operating Plan, FY 2013 includes rescissions per P.L.113-6 Division G, Section 3001(b)(1)(B) and Division G, Section 3004(c)(1) and reductions due to sequestration per BBEDCA Section 215A.

FY 2014 reflects funding amounts specified in P.L. 113-76, Consolidated Appropriations Act, 2014, including amounts noted in the Explanatory Statement. Where amounts were not specified, no amount is shown in the budget table.

Funds associated with out-year estimates for programmatic construction remain in programmatic accounts.

National Aeronautics and Space Administration

Charles F. Bolden, Jr.



Nominated by President Barack Obama and confirmed by the U.S. Senate, retired Marine Corps Maj. Gen. Charles Frank Bolden, Jr., began his duties as the twelfth Administrator of the National Aeronautics and Space Administration on July 17, 2009. As Administrator, he leads the NASA team and manages its resources to advance the agency's missions and goals.

Bolden's confirmation marks the beginning of his second stint with the nation's space agency. His 34-year career with the Marine Corps included 14 years as a member of NASA's Astronaut Office. After joining the office in 1980, he traveled to orbit four times aboard the space shuttle between 1986 and 1994, commanding two of the missions. His flights included deployment of the Hubble Space Telescope and the first joint U.S.-Russian shuttle mission, which featured a cosmonaut as a member of his crew. Prior to Bolden's nomination for the NASA Administrator's job, he was employed as the Chief Executive Officer of JACKandPANTHER LLC, a small business enterprise providing leadership, military and aerospace consulting, and motivational speaking.

A resident of Houston, Bolden was born Aug. 19, 1946, in Columbia, S.C. He graduated from C. A. Johnson High School in 1964 and received an appointment to the U.S. Naval Academy. Bolden earned a bachelor of science degree in electrical science in 1968 and was commissioned as a second lieutenant in the Marine Corps. After completing flight training in 1970, he became a naval aviator. Bolden flew more than 100 combat missions in North and South Vietnam, Laos, and Cambodia, while stationed in Namphong, Thailand, from 1972-1973.

After returning to the U.S., Bolden served in a variety of positions in the Marine Corps in California and earned a master of science degree in systems management from the University of Southern California in 1977. Following graduation, he was assigned to the Naval Test Pilot School at Patuxent River, Md., and completed his training in 1979. While working at the Naval Air Test Center's Systems Engineering and Strike Aircraft Test Directorates, he tested a variety of ground attack aircraft until his selection as an astronaut candidate in 1980.

Bolden's NASA astronaut career included technical assignments as the Astronaut Office Safety Officer; Technical Assistant to the director of Flight Crew Operations; Special Assistant to the Director of the Johnson Space Center; Chief of the Safety Division at Johnson (overseeing safety efforts for the return to flight after the 1986 Challenger accident); lead astronaut for vehicle test and checkout at the Kennedy Space Center; and Assistant Deputy Administrator at NASA Headquarters. After his final space shuttle flight in 1994, he left the agency to return to active duty the operating forces in the Marine Corps as the Deputy Commandant of Midshipmen at the U.S. Naval Academy.

Bolden was assigned as the Deputy Commanding General of the 1st Marine Expeditionary Force in the Pacific in 1997. During the first half of 1998, he served as Commanding General of the 1st Marine Expeditionary Force Forward in support of Operation Desert Thunder in Kuwait. Bolden was promoted to his final rank of major general in July 1998 and named Deputy Commander of U.S. Forces in Japan. He later served as the Commanding General of the 3rd Marine Aircraft Wing at Marine Corps Air Station Miramar in San Diego, Calif., from 2000 until 2002, before retiring from the Marine Corps in 2003. Bolden's many military decorations include the Defense Superior Service Medal and the Distinguished Flying Cross. He was inducted into the U.S. Astronaut Hall of Fame in May 2006.

Bolden is married to the former Alexis (Jackie) Walker of Columbia, S.C. The couple has two children: Anthony Che, a lieutenant colonel in the Marine Corps who is married to the former Penelope McDougal of Sydney, Australia, and Kelly Michelle, a medical doctor now serving a fellowship in plastic surgery.

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NASA Administrator

Chairman PALAZZO. I thank General Bolden for his testimony, reminding Members that Committee rules limit questioning to five minutes. The Chair will at this point open the round of questions. The Chair recognizes himself for five minutes.

During our budget hearing last year, I asked you about the Administration's $60 million reduction to the SLS program in its fiscal 2014 budget request. At the time you believed the discrepancy was more about how the money was classified than an actual reduction. This year, the Administration has an SLS vehicle development line very clearly broken out and shows a $219 million reduction to vehicle development. At the time the omnibus passed, you praised the appropriation for keeping NASA's Deep Space Exploration program on track. If the $1.6 billion for SLS will simply keep it on track, how will a $219 million cut affect it, and what activities will you plan to stop in Fiscal Year 2015 that are funded in Fiscal Year 2014?

Mr. BOLDEN. Mr. Chairman, if I can get the chart back up one more time, I think that will help me explain my logic and why I think the budget as we requested suffices for keeping us on track to Mars.

There are three relevant areas here. We are Earth reliant right now, and we want to get away from that. We need a proving ground before we can go to Mars. There is so much we don't know. We have got to have a place, and preferably somewhere within a day or two from Earth, and that happens to be the Earth-Moon system, so that is why we selected the Asteroid Redirect Mission as our particular steppingstone to go to Mars. In low-Earth orbit, we have the International Space Station, which is viable and functioning.

So we feel that we have got to do first things first, and the first thing for us is making sure that we have a reliable Earth-reliant system. If I don't get commercial crew, that Earth-reliant area becomes weakened. I do not want to be reliant on the Russians to get my crews to the International Space Station. So I don't need a Space Launch System and Orion if I can't get my crews to low-Earth orbit. If we continue to depend on the Russians, then everything else is in jeopardy. So Commercial Crew is the critical need for this Nation right now.

Chairman PALAZZO. Okay. I mean, I might have a quick question on Commercial Crew as well. So basically you are saying you are reducing the SLS/Orion budget to fund Commercial Crew?

General BOLDEN. Mr. Chairman, I am not really saying that I am reducing the SLS/Orion budget.

Chairman PALAZZO. It is a $219 million cut, so what are we going to be putting it on?

General BOLDEN. In the time that I have been the NASA Administrator, we have invested $12.5 billion into space exploration, into SLS, Orion and the ground systems, $12.5 billion. Over an equivalent time, if we had the Shuttle, we would have spent $12 billion. So we have invested more in SLS and Orion than we would have spent on the Shuttle if it were still around. The President has requested $109 billion since I became the NASA Administrator. Fifty-two percent—almost 50 percent of that, $52 billion, has been requested for human exploration. So, I think we are quibbling about

hundreds of millions of dollars in a multibillion-dollar budget, and since I am the CEO of the company trying to get us on this path to Mars, I think that all we need to do is continue on the road we are. I would invite the Members to go to Michoud. I would invite the Members to go to the Kennedy Space Center. They will see Orion ready to fly next fall. So we are producing. We are not cutting back on anything. We have hardware in production right now.

Chairman PALAZZO. I appreciate that answer. It doesn't quite, you know, satisfy my question but I will follow up with you at a later time to get more information.

For the past two years, you have graciously come before Congress and testified that without receiving full funding for Commercial Crew, NASA would not be able to deliver certified crew transfer service to the ISS. However, despite receiving less than the request both years, NASA continues to claim that these services will be available by 2017. It would seem that one of three things happened with this program. Either NASA consistently requested more money than it needed for the program, or NASA won't be able to meet the 2017 launch schedule, or there is more flexibility in the acquisition strategy than NASA is leading on. How can you say that if you don't get full funding for Commercial Crew this year that the schedule will slip when this is the exact same thing you said in previous years, and yet just this week NASA claimed to be on schedule for 2017?

General BOLDEN. Mr. Chairman, if the Committee would indulge me, I would ask everybody to think back to my first hearings when I became the NASA Administrator, and when we started talking about Commercial Crew at that time, we were requesting a billion dollars. We requested a billion dollars over the next six years for a total of $6 billion for Commercial Crew. That was based on my estimate and that of the Augustine Committee that said one provider would cost about $2.5 billion. We multiplied it by two, and I added a billion, so that is how I got the $6 billion. We got zero the first year. The second year, we got $525 million. At the time we were targeting 2015 for the availability of Commercial Crew. We would now find ourselves months away from launching Americans from American soil, and I wouldn't have to worry about paying the Russians another $450 million. Over time when I kept coming back to the Committee, I said if we don't get full funding, we are going to slip. I came back finally and said we have slipped. We now will not have Commercial Crew available until 2015—2017, and we may not have the competition that I need. The Committee implored us to down-select to one. We said please don't make us do that; we need competition. So I just want to remind everybody of the history of Commercial Crew and how we got here today.

We are now faced with a 2017 availability from 2015, so I am not—I have been consistent. I have said we will slip if we don't get the funding. We have slipped two years. I am saying the same thing again today. If we don't get what the President requested, I can't guarantee 2017, I can't guarantee competition, and we will continue to pay the Russians. I don't like that.

Chairman PALAZZO. So even though in previous years you said the same thing but you still contend that we are going to be on schedule for 2017?

General BOLDEN. Mr. Chairman, I need for everybody to understand what I just said. I said 2015 the first time I testified before this Committee. I said we can do that if we fund the President's budget. I came back at a subsequent point and said okay, we are not going to make 2015, we can make 2017, given the level of funding we have. We are on track to still get to 2017 if we are given the amount of money that the President requested in the 2015 budget.

Chairman PALAZZO. Well, General, I think this Committee and Congress agrees with you. We don't want to be solely reliant on the Russians for human access to space. I mean, we want to launch American astronauts from American soil on American rockets.

General BOLDEN. Mr. Chairman, as I said before, budgets are about choices. This Committee, this Congress chose to rely on the Russians because they chose not to accept the President's recommendation and request for full funding for Commercial Crew. You can't have it both ways.

Chairman PALAZZO. Well, we are getting away from that so, I mean——

General BOLDEN. We are not away from it yet because I don't have a——

Chairman PALAZZO. We are not one to continue to rely on the Russians but, again, we have serious budget constraints, not just dealing with NASA's budget but with all of our discretionary spending. We have—we are looking at some serious issues, and we know the world is not becoming a safer place; it is becoming much more dangerous, and you know, we have to make sure that we have a presence in space. If not, those friends that aren't so friendly to us will have a presence, and you as a General in the Marine Corps knows whoever has the high ground pretty much dominates the battle space.

So with that, my time has expired. I will turn to the Ranking Member for her questions.

Ms. EDWARDS. Thank you, Mr. Chairman, and I will take advantage of that extra two minutes and 48 seconds. Thanks.

I want to continue this line of questioning, though, because I look in your prepared statement, Mr. Administrator, you indicate that we can stay on track to launch astronauts to the ISS from American soil by the end of 2017 if Congress fully funds your 2015 budget request. That budget request is $848.3 million, and last year you received 696.

General BOLDEN. Yes, ma'am.

Ms. EDWARDS. So the choice for Congress is that in order for you to commit to making that 2017 date, we have to commit to the 848.3. Is that correct?

General BOLDEN. Yes, ma'am, that is correct.

Ms. EDWARDS. And in addition to that, I want to know then what your confidence level is if we are at 848.3.

General BOLDEN. My confidence level of making 2017 if we are at 848.3 is good. It is high for making 2017. My confidence level for making 2017 with robust competition is not as high. You know, that is the reason that we put $150 million into the Opportunity Fund——

Ms. EDWARDS. Okay. I want to——

General BOLDEN. —because that would get us to a billion dollars.

Ms. EDWARDS. I want to get back to what informs your confidence because there—we had requested, the Committee requested an independent cost estimate that wasn't done, and so tell me what the basis is for your 2017 confidence level.

General BOLDEN. My basis for everything, every statement I make before this Committee is my leadership team, and Bill Gerstenmaier heads up the Human Exploration and Operations Mission Directorate. Until I get half as smart as they are, that is going to be my—and we are also talking to industry. We are dependent on American industry contributing the major portion of what is going into the Commercial Crew program. We are able to stay on track so far but I don't know how much SpaceX, Boeing, Sierra Nevada has put of their own personal funds into Commercial Crew. I know they have put more than we have. So the difference to keep us on track has been because the companies are expecting that we will fully fund it one of these days and they continue to up their investment would be my guess.

Ms. EDWARDS. So let me just ask, so with the 2014 enacted levels of funding for SLS/Orion, and what you requested, resulting then you are saying in the slip to 2017——

General BOLDEN. No, the 2017 slip came long before that.

Ms. EDWARDS. So what—if Congress doesn't fund fully at 848.3, what development activities will have to be delayed in order to accommodate——

General BOLDEN. Milestone achievements on the part of the Commercial Crew providers, compliance with human ratings standards and other requirements because they will be under contract. When we award the contract, we have to stretch that contract out. That is what always happens. You have less money. We have two things we can work with. We can work with cost and schedule. If I don't have enough money, the schedule stretches out. It always does.

In Commercial Crew under the Space Act Agreement, I didn't have to worry as much about the cost because that was a partnership, and so the companies were also putting in money as necessary to make sure that they stayed on track with their milestones.

Ms. EDWARDS. So let me just ask again, and maybe you have it, but can you provide to us the independent cost assessment that was done that informs your belief and your confidence in the 2017 date for Commercial Crew?

General BOLDEN. Yes, ma'am. I am told that that will be available shortly, so we will get that to the Subcommittee.

Ms. EDWARDS. Okay. We are counting on that, Mr. Administrator.

General BOLDEN. Yes, ma'am.

Ms. EDWARDS. And then I want to ask you on Commercial Crew, I am concerned about the possibility of a premature selection of Commercial Crew transportation service provider and how that translates into safety for our astronauts. So the Aerospace Safety Advisory Panel, the ASAP, recommended in its annual report for 2013 that competition be maintained until safety confidence is achieved. So how are you dealing with these safety considerations?

And if we are going to keep the process open for competition, how do you inject safety in there?

General BOLDEN. We inject safety by putting the competition in and writing contracts that allow us to get into the facilities and levy additional regulations if necessary requirements. We are confident right now. We just went through a contract—we are in the middle of a contract process right now. It is called Commercial Crew Capabilities Assessment, and it is the contract that over the last year has allowed us to work with the companies. We ask them, demonstrate to us how you are going to meet our safety standards, demonstrate to us how you are going to document meeting those safety standards, show us how you are going to handle hazard reports. We are already doing that with them, and we have worked with them for years to reach agreements on what those standards would be. They can meet or exceed NASA standards, and in many cases, that is exactly what they are going to do.

Ms. EDWARDS. So——

General BOLDEN. They will cite their own standard.

Ms. EDWARDS. So my time has more than expired, but let me just read to you from the ASAP annual report: "If NASA down-selects to one provider before the selectee has demonstrated that its design can meet the required level of safety, there is the ultimate potential that the provider may not be able to meet the requirements for a number of reasons including cost. In such a situation, NASA will have little alternative because it has already down-selected"—those are my words—"but to either move the safety goalpost or to incur an overrun and/or a schedule slip. If competition is maintained, NASA may have alternatives other than accepting a less safe design, unnecessary higher cost or a late delivery." I only share that with the Committee and you because it is very clear that if we move toward, one, depending on what our budget numbers are, then the likelihood that we are not paying the kind of attention in Commercial Crew to safety actually goes up, not down.

General BOLDEN. No, ma'am. The likelihood that we are going to pay less attention to safety is zero. Safety is something that I do, that Bill Gerstenmaier does, that the Commercial Crew Program Manager does, and that is, our attention to safety is independent of cost. We may become even more vigilant, which means the schedule is really going to stretch out because we are going to require additional tests. That is what happens when you don't have competition. The vendor begins to think that okay, you are relying on me, you have got to have it at this date and you have to take what we want. That is not the case. We are not going to do that.

Ms. EDWARDS. I apologize but I am now at exactly two minutes and 50 seconds.

Chairman PALAZZO. I now recognize the gentleman from Texas, Mr. Smith.

Chairman SMITH. Thank you, Mr. Chairman.

Administrator Bolden, I think we are all regretful that we are relying upon the Russians to take American astronauts to the International Space Station. Given the turmoil in the Ukraine, given our current relationship with Russia, which is obviously not good, are you aware of any threat that Russia might refuse to take

American astronauts to the International Space Station for any reason?

General BOLDEN. I am not aware of any threat, and I am comfortable because we talk to the Russians every day. We talk to Roscosmos. There are a lot of people in Russia. Our partner is not Russia; our partner is Roscosmos, the Russian space agency, and we are confident that they are just as interested and just as intent on maintaining that partnership as we are.

Chairman SMITH. Hopefully the problems on Earth are not going to be——

General BOLDEN. This is not the first time that we have had this type of problem. When the Russians went into Georgia, the partnership remained robust, and we—that is what we are trying to do right now.

Chairman SMITH. Okay. Thank you.

Let me go to my next question, and this is about ARM. Last May, NASA Advisory Council Chairman Dr. Steve Squyres testified "I see no obvious connection between the Asteroid Retrieval Mission and any of the technologies or capabilities that are required for Martian exploration."

I understand that NASA is undertaking a study on the possibility of a Mars flyby in 2021. Is that the case?

General BOLDEN. That is not the case as far as I know. We have been working with Inspiration Mars, which is I think what you are talking about. We agreed that we would allow them to take NASA technology. They can use NASA facilities. We will partner with——

Chairman SMITH. Perhaps I misunderstood you because I thought you specifically told me in response to a letter that I sent you that you would review that.

General BOLDEN. Oh, I thought you asked if we were doing a study. We are not doing a study.

Chairman SMITH. Okay. It looks like you reviewed the 2018. Are you reviewing the 2021?

General BOLDEN. We are reviewing any efforts that NASA might make in supporting Inspiration Mars.

Chairman SMITH. So you are not making any official evaluation of it?

General BOLDEN. We continue to make evaluation of it as they come back. This started out as a partnership where they needed nothing from NASA except do not talk bad about——

Chairman SMITH. Maybe I misunderstood your letter to me. I thought you were undertaking a review, but you are not.

General BOLDEN. We are not undertaking a formal review where we go out and hire an independent firm, if that is what you mean.

Chairman SMITH. That is not what I was asking. I was asking about an internal review.

General BOLDEN. We are constantly reviewing whether or not Inspiration Mars and the Mars flyby is a suitable alternative for us in getting to Mars, putting humans on Mars.

Chairman SMITH. I just quoted the Chairman of the NASA Advisory Council as saying that there was no obvious connection between——

General BOLDEN. I think if you talk to Steve Squyres today, because of where we are, the maturity of the——

Chairman SMITH. I don't doubt you could put political pressure on him but——

General BOLDEN. I don't put any pressure on him. No, that is why he is the Chairman of——

Chairman SMITH. He testified before this Committee. He was very clear.

General BOLDEN. I don't——

Chairman SMITH. And what I just said was a direct quote.

General BOLDEN. Mr. Chairman, just to be clear, I put no pressure—I can't put pressure on Steve Squyres. He chairs the——

Chairman SMITH. Well, then, as far as I am concerned, his testimony before the Committee stands and the quote that I just gave you is still valid, unless you have got other information.

General BOLDEN. I have other information, which is talking to Steve Squyres weekly, and Steve Squyres counseled me, don't make this seem like you are going to save the planet; show us, the NASA Advisory Committee, how this is relevant to getting people to Mars. We have subsequently done that, and if you can put the chart back up again, you know, I am not going to dwell on the chart but we——

Chairman SMITH. The last I heard, he said there is no connection, so I am going to take him at his word until I hear from him.

Let me go to a different subject, and this is in regard to the James Webb Telescope and the test program as well, a happier subject. We expect James Webb to launch in 2018. I think tests may be 2017. What information might we glean from those two telescopes that will help us in our understanding of astrobiology?

General BOLDEN. James Webb actually will enable us to look into the atmosphere of some of, if not all of, the exoplanets that have been discovered through Keppler and other observatories. So James Webb will continue to revolutionize our understanding of our universe. Hubble has rewritten textbooks. James Webb is advertised to be 100 times more potent and more powerful.

Chairman SMITH. Specifically, what might we learn about astrobiology as a result of those?

General BOLDEN. We might learn what the makeup of exoplanet number whatever it is, what its atmosphere is.

Chairman PALAZZO. And then—okay. Good.

General BOLDEN. That will tell us whether or not there is a possibility of life existing on an exoplanet.

Chairman SMITH. Right. That is my hope as well. Thank you, Administrator.

Thank you, Mr. Chairman.

Chairman PALAZZO. I now recognize the gentlewoman from Texas, Mrs. Johnson—my apologies. Ms. Bonamici.

Ms. BONAMICI. Thank you very much, Mr. Chairman.

Chairman PALAZZO. Of Oregon, by the way.

Ms. BONAMICI. Thank you.

Ambassador Bolden, welcome back, and thanks, as always, for your informative testimony. We really appreciate that.

I want to start by mentioning, as you did, the importance of investing in the Earth Science programs at NASA. I want to acknowledge the economic impact of that research, especially in the district I am proud to represent. I can't overstate the importance

of accurate climate and weather forecasting to my constituencies from agriculture, the fishing community, so continued investment in that underlying science that helps us understand climate is important and significant. I know that last year NASA inherited from NOAA some climate sensors that were formerly a part of the NOAA-funded JPSS program but NASA only received funding for Fiscal Year 2014 for that activity, so has that been remedied going forward?

General BOLDEN. We think it is in the process of being remedied, and in fact, if I remember correctly, we plan to take the two climate sensors, and they will actually become a part of the International Space Station. We had the option of making them free flyers, which would have been relatively expensive, the Earth Science community working with the Human Exploration and Mission Operations Directorate and are trying to enhance the utilization of station. We are beginning—as you may know, we are beginning to put more and more Earth Science missions on the International Space Station. That is where we intend to put them.

Ms. BONAMICI. Terrific. Thank you.

And then I wanted to follow up on the comments that were made by a couple of my colleagues already about the concern about investing in the Education mission. As someone who discusses that issue frequently both in this Committee and the Education Committee, STEM education is a priority of course of many of my colleagues on both sides of the aisle, of our constituency. What I want to talk about today is the NASA Space Grant program. Recently I met with representatives from the Oregon NASA Space Grant Consortium, and our conversation largely focused on the importance of keeping students engaged in STEM, and I will tell you, there are a couple of examples that show how important this is. One of them is that students from McMinnville High School in my district on April 6th coming right up are doing a nano lab launch, and the difference that this is making to these students in McMinnville High School, they are thrilled that they have two separate nano labs going up to the ISS. They are so excited. And when we are talking about building people who want to work in this field, looking at someone also from Oregon, Victor Dang, who is now a full-time structures engineer for SpaceX, had an internship at the Johnson Space Center, said it was an amazing opportunity, he couldn't have done without the Space Grant program, interned also at Ames Research Center where he said the opportunity had an incredible impact on his career. It was his first industry experience but it solidified his desire to pursue a career in aerospace. He said, "It was one of the most fun summers I ever had. It inspired me to seek opportunities that would allow him to travel to new places."

So as we are trying to build not only people to work in the field but also make sure that the public understands the benefits of space exploration, can you talk a bit about how this Space Grant program is engaged in getting students into STEM fields but also talk about the role in educating the public at large about NASA's educational work, and know that many of us are very concerned about the reductions in education.

General BOLDEN. Very briefly, for the benefit of those who may not understand Space Grant or know very much about it, every

state in the Nation has a Space Grant consortium and it is usually headquartered in the land-grant institution of that state. So it is a dependable source of STEM reference and education for NASA. We have asked them over the past few years to extend their work actually down into the K–12 level where they were very uncomfortable at first, but they now as a result of working with us on the Summer of Innovation, for example, which is probably where the young man in school has learned about STEM education, we now have the Space Grant consortium, and many states, they are the responsible entity for making sure that Summer of Innovation is conducted in their states over a period of time. So it is a very good program.

Ms. BONAMICI. And do you expect that that program is going to be cut? Because there are these sharp reductions in the educational activities.

General BOLDEN. One of the things that I never have to worry about is reductions in Space Grant. Space Grant and MUREP and other programs are those that we ask for what we think will be required to maintain them, and you all always help, so I am not worried about funding for Space Grant.

Ms. BONAMICI. Well, thank you. I am almost out of time. I yield back. Thank you, Mr. Chairman.

Chairman PALAZZO. I now recognize the gentleman from Alabama, Mr. Brooks.

Mr. BROOKS. Thank you, Mr. Chairman.

I must admit that I am somewhat astonished by your testimony that shifts responsibility from this Administration to Congress for American's current inability to launch astronauts into space. Let us be clear for a moment. This Administration made the unilateral 2010 decision to cancel NASA's human spaceflight Constellation program, thereby delaying America's return to human spaceflight. This Administration made the decision to mothball our Space Shuttles and put them in museums rather than keeping them available should circumstances or emergencies dictate their use. This Administration has grown America's welfare, wealth transfer programs to over $750 billion per year, more than 40 times NASA's budget, welfare programs that put a higher priority on buying election votes no matter the loss of funding for NASA, national defense or other productive functions of the federal government.

Now I hear testimony that this Administration wants to invest in America, quote, unquote, when the Space Launch System, NASA's next human spaceflight program, was forced on this Administration by Alabama Senator Richard Shelby and other Senators and Congressmen who believe in Americans' exceptionalism in space.

With that as a backdrop, as you know, Russia has engaged in acts of war against the Ukraine in the Crimea. America's response has been rather anemic economic sanctions, sanctions designed to provide maximum domestic political cover without any hope of causing Russia to leave the Crimea. Recent intelligence information raises the concern that Russia may go beyond the Crimea and attack eastern Ukraine. All of this raises the specter that this Administration will impose more economic sanctions which in turn risk that Russia will respond by denying America access to the

International Space Station, and they can do that because we are reliant on Russia to get to the International Space Station. In the time remaining, Mr. Administrator, please describe to this Committee what NASA's plan is to put American astronauts on the International Space Station should Russia say they are no longer going to give us a ride to the Space Station?

General BOLDEN. Mr. Chairman, may I get the chart again? Because—and Congressman Brooks, I am not going to engage in a debate about history. It is a fact that the decision to phase out the Shuttle was not made by the Obama Administration. That decision was made following the recommendation of the Columbia Accident Investigation Board in 2004 under the Bush Administration.

Mr. BROOKS. Excuse me, if I might interject, when the space Shuttle was mothballed, President Obama was President of the United States.

General BOLDEN. That is right.

Mr. BROOKS. He could have made any decision he wanted to make—wait a minute. Let me finish. He could have made the decision to have continued to use the Space Shuttle or he could have made the decision to keep it available in the event of emergencies. He chose not to.

General BOLDEN. Congressman Brooks, I will just make one statement. I was the one who recommended to the President that we phase the Shuttle out. I would have recommended we phase it out quicker. I just mentioned we were spending $12 billion over the same period of time that we have spent $12.5 billion on SLS and Orion——

Mr. BROOKS. Okay. Let me interject again.

General BOLDEN. Congressman——

Mr. BROOKS. No, wait a second. You said you were not going to go over history. You were able to divert from my question to history. My question was, if Russia cuts us off today because of the events in the Ukraine or elsewhere in the world, what is NASA's plan to get us to that Space Station?

General BOLDEN. Congressman, we engage in contingency planning every single day, contingency planning for Russia refusing to take us to the International Space Station is not a—it is something that I consider to be feasible right now because Russia is dependent upon the United States to operate the International Space Station when it comes to power, when it comes to everyday operations. That is all done by the United States. Russia has one thing that we need: access. If the International Space Station——

Mr. BROOKS. Okay. Back to my question.

General BOLDEN. Listen——

Mr. BROOKS. Is it your testimony that America has no plan because you don't think it is a possibility to worry about?

General BOLDEN. This is like asteroids. We have a plan. The plan needs to be funded. The plan is Commercial Crew. If the Congress chooses not to fund Commercial Crew, we—this Nation has no plan.

Mr. BROOKS. Okay. I have looked at your written statement, and it says and consistent with your oral statement that basically we are looking at the end of 2017, which is three and a half years

away. Is that the plan if Russia decides to terminate our access to the International Space Station?

General BOLDEN. Congressman Brooks, I am confident that based on my conversation with my Russian counterparts that they are equally worried about terminating activity on the International Space Station, so I am not going to deal in suppositions. I don't expect that our partners will abandon the International Space Station, which would——

Mr. BROOKS. Okay. Mr. Chairman, I see my time is expiring. I appreciate the witness's insight. But if all I am hearing is that our only plan is three and a half years away, I have to worry about what happens if Russia does cut us off as our relationship with Russia continues to deteriorate based on Russian acts of war in the Ukraine and Crimea.

Thank you, Mr. Chairman, for indulging me.

Chairman PALAZZO. I now recognize the gentleman from California, Mr. Bera.

Mr. BERA. Thank you, Mr. Chairman. Thank you, Ranking Member Edwards.

You know, let us not dwell on the past. Let us actually look to the future and think about where we want to go, because that is what we do. We are informed by the past but we also plan for the future.

General Bolden, just playing off of what my colleague talked about, it is my impression that we also have leverage with regard to the International Space Station.

General BOLDEN. Exactly.

Mr. BERA. So in a partnership, we have got that leverage, they have got some leverage. But the end goal, if we are looking toward the future, is commercial space travel and moving folks forward. When I do look at the building blocks, and our conversations previously, we do really have a long-term goal to have human space travel to Mars, and you are laying out some steps here and so forth.

I had a chance to visit the SpaceX plant down in southern California recently, and it does look like they are also fairly quickly advancing. Obviously they have been able to take supplies up to the Space Station and they are now also advancing fairly quickly on commercial space travel with humans. Can you give us an update about the partnership between NASA and the commercial space entities and so forth?

General BOLDEN. I think we should all be proud that during the period of time that I have been the NASA Administrator in the Obama Administration, we have stood up a commercial cargo capability. So we are not dependent on any international partners anymore for getting cargo to space. We are diligently working with some of those same partners plus others to bring about a capability in the United States to have a Commercial Crew capability. NASA does not deal in low-Earth orbit access anymore, nor should we, because we have to use that money in order to execute a deep space exploration program.

Mr. BERA. Great. Can you expand on the Asteroid Retrieval Mission as a building block and a step into going to deep space as well as returning from deep space?

General BOLDEN. There are things that we need if we want to go to Mars, and I hope that all of us in this room, particularly those on the Committee, will agree with me that NASA's, America's, the world's ultimate goal in our lifetime is to put—to see humans on Mars. If I can get the chart back up because it would really be helpful? In order to get to Mars, there are things we don't have. We don't have sufficient propulsion to take cargo there because you don't want to have to utilize your crew vehicle to take cargo. It would take multiple SLS missions to get the amount of cargo to Mars to sustain a human inhabitation there. We need increased capability in something like solar electric propulsion. We need to be able to test it. And so our proving ground is the Earth-Moon system, the cislunar orbit where we intend to take the asteroid so that we can interact with it, we can fly Orion there, we can do things, we can develop procedures for extravehicular activity, we can develop procedures for proximity operations, things that we cannot do in low-Earth orbit because that system is different than what we know in low-Earth orbit. So I need a proving ground. The Moon is two days away. If something goes wrong there, we can come home. Once we launch to Mars in the 2030s, the crew is eight months away. So imagine Apollo 13. The crew survived because it was a loop around the Moon and nature took care of it, to be quite honest. An Apollo 13-like incident, the side of the service module blows out right after liftoff, we are going eight months to Mars and then another eight months to come back or more. So we have got to get it right, and our proving ground is cislunar orbit with the asteroid mission where we can develop the life support systems that are robust. We can't have a cooling system that fails. We can't have the kinds of things that happen sometimes in the International Space Station. That is why Station is used to develop the technologies. They have got to be better, got to be more robust.

Mr. BERA. And again, if we stick with this theme of wanting to be forward-looking, wanting to dream, which is what we did as kids, right, when we looked at the Apollo missions and putting a person on the Moon, we dreamt big and then we went out and did it. That is what we have to do right now.

With this goal of human space travel to Mars, it is going to—we don't know how we are going to get there just yet but we have got to think about those technologies and we have got to start making those investments. Would that be accurate?

General BOLDEN. That is very accurate. It is now time for us, and I have asked our people to start thinking about okay, we are approaching 2030. SLS and Orion have been proven. We are getting ready to go to Mars. What should we be thinking about now? You got to get to the surface. We haven't even started talking about landers. We have not even started talking about surface systems. That is where the international partners and commercial partners, I think, are going to be vital.

Put the chart up one more time, because I need for people to visualize this. This is hard. If you look at Earth reliant, we cannot get to deep space, we can't sustain operations in deep space if we have to come back to Earth every time to pick up stuff. Congressman Rohrabacher knows this. We go through this all the time. We need things like cryogenic propellant and storage. I don't need it

right now. So he and I disagree on what the timing is. We are in the just-in-time business. The reason I don't spend the money that you would like to have me spend on SLS is because I don't need a 130-metric-ton vehicle right now. I do need a commercial vehicle that I can send my astronauts to low-Earth orbit. Now, we—hopefully everyone agrees we are going to Mars. If we do, hopefully everyone agrees that we have got to crawl, walk, run, and this is a crawl, walk, run. We have got to have proven technology.

Chairman PALAZZO. The gentleman's time is expired.

Mr. BERA. Great. Thank you.

Chairman PALAZZO. I now recognize the gentleman from California, Mr. Rohrabacher.

Mr. ROHRABACHER. Well, perhaps a crawl, walk, orbit would be——

General BOLDEN. That is good.

Mr. ROHRABACHER. How did you know what I was going to ask?

General BOLDEN. I was hoping you would because I need for people to be consistent in what they ask, and you have been consistent.

Mr. ROHRABACHER. Boy, I didn't expect all these great compliments.

General BOLDEN. I try to speak the truth.

Mr. ROHRABACHER. Thank you, General. Well, let us get to the first ride. Two issues I wanted to talk to you about. One was what you brought up, refueling in space, and let me just note for the record, not all of us do believe that getting to—putting people, you know, on Mars should be our number one goal in space right now.

General BOLDEN. Yeah.

Mr. ROHRABACHER. It is expensive, and making that our number one goal reflects taking away resources from other projects that might be more important to humankind than just what is a symbolic mission of putting a human being on Mars, considering that we have robots and rovers and all sorts of other things that are on Mars already.

But let us go to that. When we are talking about the option of refueling in space, would that not give us a great deal of leverage to accomplish other missions in space, perhaps on the Moon, perhaps other goals that we would like to achieve at a much more cost-effective rate because we wouldn't have to build such a huge rocket that SLS is going to cost tens of billions of dollars?

General BOLDEN. We don't know that it would be much more cost-effective because to get the type of depot in space—and we have talked about this before. The number of flights required to get the type of depot in space that we need is extensive, and so while an Atlas V or a Falcon 9 may cost significantly less than an SLS, by the time you fly 10, 12 Atlas Vs or Falcon 9s, you have exceeded the cost of an SLS. So for getting humans into deep space, for getting large payloads, large scientific payloads into deep space, you want something like an SLS so we don't have to do these Venus flybys to Jupiter. We want to be able to go direct. SLS will give us that capability in time. We are not ready yet. We don't need that capability yet, so we have to do as you said, we need to cislunar orbit to develop the technologies, low-Earth orbit to develop the technologies, and we are trying to do that. We are using

ground tests right now for cryogenic propellant and storage. We are not going away from it.

Mr. ROHRABACHER. I am watching that closely, and let me just say that I think that that presents us a much more cost-effective way of achieving specific goals rather than heading for a goal that would be so expensive that it would drain other potential uses in space, projects in space.

Now, let me ask you this. Are you confident that if an object from space that was discovered or there is an object in space that threatens to cause massive damage on our planet, are you confident that that object will be detected and that we can deflect it?

General BOLDEN. I am highly confident that that object can be detected. In fact, if there is an object that is larger than a kilometer that threatens Earth, we probably already have identified it and it is in the 97 percent or 98 percent of those objects that have already been identified. We know when it is going to be but nothing in the next 100 years in that category. If it is less than 140 meters, I am less confident that we have—in fact, I know we have not identified it yet but we are developing the capability to do that. Deflection, nothing.

And Congressman Posey is probably going to ask me the same thing as he did in the asteroid. We are trying. The Asteroid Redirect Mission will inform our—it won't—I don't want to fool people. We are not going to save the planet with the Asteroid Redirect Mission. It will inform our capability to answer your question and his question from the asteroid hearing which is, does the United States have the capability of protecting the planet if we can identify something fast enough. In the future, in the near future, when we fly the Asteroid Redirect Mission, that will inform our ability for me or whoever is sitting in this chair then to say I am very confident that we can deflect anything that is inbound to Earth. It will inform us. It won't give us the capability.

Mr. ROHRABACHER. I don't want to quibble with the word. "Can" and "will" are two different things.

General BOLDEN. Okay.

Mr. ROHRABACHER. With that, we will deflect an object that could destroy and murder, you know, millions of people.

Let me ask——

General BOLDEN. We will have that capability, I am confident.

Mr. ROHRABACHER. Okay. One last quickly here. Is there an established procedure and chain of command to take the actions that would be necessary if we do spot this maybe three percent chance that there is a huge object heading toward us? Is there a chain of command and the necessary procedures to actually make the decisions and take over and get the job done?

General BOLDEN. There are procedures in place. There is a definite change of command, or a chain of command. In fact, I am going to be traveling to Langley Research Center next week. That is my devolution facility. Every year we practice a continuity of operations nationwide or government-wide, so I will be moving with my chief of staff and the Associate Administrator to Langley because something bad is happening to Washington. FEMA becomes a critical player in the role. The National Command Authority springs into action. The President is the guy that makes all the big

decisions and the National Security Council, and NASA is a teeny weeny little player in there. We provide data as we continue to do.

Mr. ROHRABACHER. If a near-Earth object was coming——

General BOLDEN. If a near-Earth object were coming, that would become an impending national disaster like a hurricane or other kinds of things, and there are distinct procedures in place to what FEMA would do with the Nation to get prepared. Something like a near-Earth object, we don't presently have the capability like a hurricane to give you a percentage probability that is going to strike New York or, I mean, you know, it is going to strike Earth. That is what we can tell you. And so—but we would have to prepare.

Mr. ROHRABACHER. Thank you, General.

Chairman PALAZZO. I now recognize the gentleman from Texas, Mr. Veasey.

Mr. VEASEY. General Bolden, good morning, and I wanted to touch on Russia again very quickly.

Most recently, one of the official sanctions because of the Ukraine crisis is Dmitry Rogozin, Deputy Premier of Defense and Space Industry. You have stated that if we provide NASA with the President's request for Commercial Crew we will have launch capability in 2017. So my question to you is, how can we accelerate our efforts to assure launch capability returns back to America?

General BOLDEN. The way to accelerate it in this case is more money, to be quite honest. I can't tell you when a company is going to think they are ready to fly but all of our partners that have given us schedules—Sierra Nevada, for example, has a scheduled launch on an Atlas V, a demonstration flight for themselves, I want to say it is 2015 or 2016. So the companies are moving very rapidly, as rapidly as they can, based on the funding that we have given them to be able to be ready to fly as soon as they can. I would be hesitant to say we could accelerate it any more than a year. But we could potentially accelerate it by a year if we were given adequate funding.

Mr. VEASEY. And——

General BOLDEN. I can't say that about everything. I can say that companies are poised.

Mr. VEASEY. Right, right, and speaking of funding, what are the impacts of reducing NASA's education programs?

General BOLDEN. NASA spends $17.6 billion on STEM education. I don't think people really get it. I spend a lot of time in classrooms. I spend a lot of time doing Skype. I spend a lot of time doing VIC with schools because I can't go to every school. I don't make a trip anywhere, particularly outside the United States, that I don't do an outreach event and try to help our partner nations with their STEM education programs because everybody faces the same thing we do.

Everyone is concerned about the reductions that they see in the Office of Education but it is making us hungry to find new ways to collaborate with other agencies. We did a program with the Department of Education. It is their 21st Century Communities and Learning program. NASA essentially did the program for them because we could bring astronauts into the classroom via downlink TV from the International Space Station. We were paid $300,000

to kind of put it together. They invested $5 million. That probably would have cost the Nation $10 million last year but we are learning how to collaborate with each other. We are not—I know everybody is worried about losing money. We are finding that synergy among Federal agencies is working for us. The 4–H is in every single county in this Nation, every single county. NASA has the Space Grant Consortium in 50 states. Compare every single county to 50 states. We are now talking about working with collaboratively 4–H. That is going to magnify greatly the number of kids that we are able to reach with STEM education enrichment. So I am not worried about our ability to do our job. STEM outreach, it is us. I mean, we do that every day.

Mr. VEASEY. In your opinion, is there any way to evaluate, you know, like whether or not these——

General BOLDEN. Oh, yeah.

Mr. VEASEY. —that would make cuts to the programs? Are there real ways to evaluate whether or not these cuts are having an impact on future achievement or, you know, we talk a lot in this Committee about being to inspire young people to, you know, want to reach certain goals as it relates to STEM-related jobs.

General BOLDEN. Without a doubt. NASA's education program this year for the first time is outcome based, which means you have got to have metrics, so we are looking at, now we are not allowed because of privacy, we can't map a child from elementary school through college. The Department of Education can. The National Science Foundation can because they are authorized to do those kinds of things. So by our collaborating with DOE, with Department of Education, and the National Science Foundation, they can do the metrics that tell us okay, how many kids that participated in Summer of Innovation last summer ten years from now are doctors or lawyers or things like that. Those are the metrics about which you speak, and although I can't do it, I can get it now based on the collaborations that we have, and it has taken time.

Everybody wants to see something now. We just started Summer of Innovation. We had to battle to get it. I think it has been around now four years, and we are seeing—we are now seeing factual data, not anecdotal data. We are looking at numbers of kids.

Mr. VEASEY. Thank you. Thank you, Mr. Chairman.

Chairman PALAZZO. I now recognize the gentleman from Florida, Mr. Posey.

Mr. POSEY. Thank you, Mr. Chairman.

General, I had a chance to thank Seth and I had a chance to thank Bob Cabana for their commonsense no-cost outreach that NASA did to reach thousands of people who were indifferent pretty much previously to space and now seem to be enthusiastic about it, and I just haven't had a chance to thank you personally for that, and I think it is great. That is how we help spread the message.

General BOLDEN. Thank you.

Mr. POSEY. A couple of things. You know, as to funding, I don't think any of us are where we would like to be with funding but I think we are in a whole lot better place than we were a year ago with the uncertainty about sequestration and so I am trying to look at a glass half full in that regard pretty much as you are.

We need a deep space plan, Moon to Mars. There is no doubt about that. And we also need low-Earth-orbit options. So I know it is tight balancing that, and in space politics, you are always going to have some that want it all one way and some that want the other way, and I hope that we will continue to understand that we do need both and go forward like that.

A concern that I have, and I discussed it briefly with Dr. Holdren yesterday, and he referred to a recent agreement that NASA has with Department of Energy over our space fuel supply. I wonder if you could bring up to date on that a little bit.

General BOLDEN. Yes, sir. We have reached an agreement with DOE. They produce the plutonium pellets that we need, and so we are still in negotiations right now trying to understand how do we help them improve their facilities, I mean, just the infrastructure that is needed to press the pellets for propulsion. We have enough right now in our stockpile to be able to fly the missions that are presently on the books for us—Mars 2020 and the like—but we have to work better with DOE to make sure that they can make the improvements to their infrastructure so that they can efficiently make the pellets that we need. We have lots of fuel but it is old and it needs new fuel to mix in it to make it good.

Mr. POSEY. They are not in the process of destroying any or getting rid of any that you are aware of or using it for anything else other than space?

General BOLDEN. I will have to take that for the record. I don't know the answer to that, sir.

Mr. POSEY. Would you just find out? I would kind of like that assurance that it is not being used elsewhere for other things or——

General BOLDEN. Yeah, I will, and I will take that for the record. I don't know.

Mr. POSEY. Okay. Thank you, General. Any other comments you would like to make about keeping on track with both?

General BOLDEN. Oh, it is a balance, and I come to this hearing, I feel better about where we are than ever before, to be quite honest. I wanted to commend the Chairman and Ranking Member because of the way they are working together. We must do better than we are doing. I don't want to sit here and say what was the responsibility of the Bush Administration, what happened in the Obama Administration. As Congressman Bera said, what is done is done. We can't undo that. We can make a difference for the future. The thing I will say is, what I am talking about, none of us are going to be sitting around here in charge. I had some young people, MLLP, they had to leave—Mid-Level Leadership Program. They are young, growing leaders in NASA, and they just wanted to see how we do this stuff. That is who is going to do all this stuff we are talking about. Deep space exploration is hard, and we cannot jump to Mars. We have to develop the technologies. We have got to be confident that our systems are going to work. That is why when Chairman Smith asked about a Mars flyby, a Mars flyby is great but it doesn't do anything for us in terms of deep space exploration. If the crew survives, and I have doubts about that—that is why I am not a fan of a one-time Mars flyby. I mean, okay, we have done a one-time Mars flyby. As great as Apollo was, and it was awesome, we never stayed on the surface of the Moon for more

than days. If we are going to go to the surface of the Moon, we better stay there for a month or two months or we are not going to learn anything about the impact of less than one gravity on the brain or on other——

Mr. POSEY. But do we agree unless at some point there is the ability to leave this Earth, the survival of our species is threatened?

General BOLDEN. I am not a fatalist, but we do need to be able to be a multi-planet species.

Mr. POSEY. A realist. We are trying to look at eternity. We are trying to look at the future.

General BOLDEN. I mean, one of these days our Sun—you and I won't see it, nobody we know will see it, but one of these days our Sun is going to burn out, it is a start, and it would be nice if we have become a multi-planet species by then and we are not just on Mars. By then people will be living in other solar systems because the solar system will go away. We got to get beyond—like my granddaughter says, she says, you are thinking about Mars, I am going way beyond that, and she is right. When the Sun gives out, this solar system goes away.

Mr. POSEY. We have to think about planting trees for future generations.

General BOLDEN. Yes, exactly.

Mr. POSEY. The shade from which we will never expect to have, and I like Neil deGrasse Tyson when he says space is truly the only investment we make for future generations.

General BOLDEN. Yes, sir. I agree.

Chairman PALAZZO. The gentleman's time is expired.

Mr. POSEY. Thank you, Mr. Chairman.

Chairman PALAZZO. I now recognize the gentleman from Arizona, Mr. Schweikert.

Mr. SCHWEIKERT. Thank you, Mr. Chairman and General.

Part of what I want to sort of have a quick dialogue is, just the mechanics internally under your review, how you set priorities and the decision making and the inputs and those things because I know you have a lot of voices and a lot of people tugging on your coat saying we want this, we want that. Something like SOFIA because—now, that was really coming online just within the last 12 months or so, correct?

General BOLDEN. SOFIA is a—I mean, it has been under development for probably 10 years.

Mr. SCHWEIKERT. But in full——

General BOLDEN. It was beginning to fly and fly well.

Mr. SCHWEIKERT. And so internally, when you are doing your prioritizations and mechanics, tell me the review process you go, and let us just use SOFIA just because I am somewhat familiar with that on how you prioritize a program like that, that you have a decade of time and money.

General BOLDEN. Inside the Science Mission Directorate, they have—I forget what they call their council, but every year they get the wise people of the science community and they evaluate our programs to see, okay, what I have asked them to do for me right now is, we have a lot of programs that have been flying for a long time, long past their planned lifetime. They are expensive. We have

to pay for those. So when we prioritize what we are going to get from our science portfolio, we try to make sure we have a balance of Earth, space, everything, and SOFIA ended up in the prioritization—SOFIA was down here. When you talk about James Webb getting ready to come online, Spitzer, other sources of data that is very similar to what SOFIA gives us, SOFIA is a unique asset.

Mr. SCHWEIKERT. And I don't want to put words in your mouth because I am——

General BOLDEN. You won't.

Mr. SCHWEIKERT. —reaching back, because I remember it may have been a year or so ago, you were actually somewhat a fan of SOFIA.

General BOLDEN. I am a fan of SOFIA. I am a fan of anything that has wings.

Mr. SCHWEIKERT. So mechanically, share with me the internal process under your authority tree on how they would prioritize SOFIA and how it ended up where it is.

General BOLDEN. We would go to the science community and ask how—based on what we expect to get in our budget, what do you want to continue to operate, and the one thing I keep cautioning is, if we are going to put new systems online, if we are going to bring about new technology, better sensors than we have today, what are you going to give up? Because the science community——

Mr. SCHWEIKERT. But does that become more of a conversation of let us enhance what we have or is it to cancel or—I mean——

General BOLDEN. Well, you never say what are we going to cancel. That is not a question. So the question is, how do we operate within our budget and provide science responsive to the scientific objectives set by the Decadal Surveys, set by the outside advisory committee, set by Congress.

Mr. SCHWEIKERT. So right now you sort of understand your budget request and where you see things going. Tell me where SOFIA sits in that.

General BOLDEN. Low.

Mr. SCHWEIKERT. So it is a low priority?

General BOLDEN. It is not a low priority. I shouldn't have said that. In comparison with other projects in the science portfolio, SOFIA did not rise to the level that we decided we were either going to terminate another program or—we have options with SOFIA, and as Dr. Holdren mentioned I think yesterday, we do have options with SOFIA. We don't know what the 2015 budget is going to be so we could end up with enough money that we could—we have not stopped flying SOFIA. Everybody is panicking. We are working with our German partners to find ways that we can enhance the utilization of SOFIA for the rest of this fiscal year. We may not put it into upgrade, for example.

Mr. SCHWEIKERT. But when you are doing your layers of priorities, Opportunity, Growth and Security Initiative and those, I am just—I am trying to get a better understanding how something like this falls in the big picture.

General BOLDEN. If you look at our list of things in the Opportunity, Growth and Security Initiative, almost every one of them is something that is either in existence right now, and I am trying to

buy down risk, $150 million to Commercial Crew if the Congress grants our request for $848 million takes it to a billion. That is buying down risk.

Mr. SCHWEIKERT. Okay. And just because my time—I had two quick—do you think the Germans would be willing to take on more of the heavy lift on the cost of——

General BOLDEN. That is one of the alternatives. However, to be very candid, they don't seem to be willing to do that.

Mr. SCHWEIKERT. If we put their flag first on the airplane?

General BOLDEN. We are looking at all alternatives for SOFIA. I will have to say, though, SOFIA is a joint project. The United States, NASA is unable to assume all responsibility for SOFIA.

Mr. SCHWEIKERT. My second—and this is just because it outside my skill set—Space Station.

General BOLDEN. Yes?

Mr. SCHWEIKERT. How long can it go unmanned, you know, if it sat there for—I mean, is there sort of a—when you cross over a maintenance curve? I am just—I am sort of curious if there is a data point.

General BOLDEN. You don't want to—I don't—I will have to take that for the record. If you really want me to tell you how long we can go if we de-man, de-orbit——

Mr. SCHWEIKERT. No, no. Let us say it sat up there for 36 months.

General BOLDEN. It can't sit up there for 36 months unoccupied. We have got to have people that are repairing—it was an ammonia pump that went out. That was an emergency. That was a contingency for which we had to do a contingency spacewalk and all that. If there is no crew, that doesn't get done.

Mr. SCHWEIKERT. So in many ways, for maintenance and just sort of—you almost——

General BOLDEN. You talk about leverage. Everybody is excited because the Russians have the leverage on transportation. When you talk about navigation, communications, power, the United States has significant leverage on the International Space Station.

Mr. SCHWEIKERT. Mr. Chairman, I am so sorry. I just looked at the clock, and I was having fun here. Thank you for your patience.

General BOLDEN. You asked great questions.

Chairman PALAZZO. All great questions. I now recognize the gentleman from New York, Mr. Collins.

Mr. COLLINS. Thank you, Mr. Chairman, and there is nothing wrong, Congressman, with having some fun.

Mr. SCHWEIKERT. Well, around here it is.

Mr. COLLINS. Yeah. Okay.

General Bolden, my question really surrounds the chart you have already showed and the human exploration roadmap that is both the authorization bills in the Senate and the House as well as the minority's version that we need to help assess us in the merits of the Asteroid Retrieval Mission. So the chart you have been, you know, showing a little bit today doesn't outline what you want to call the specific set of capabilities and technologies required to extend human presence to the surface of Mars or the mission sets necessary to demonstrate the proficiencies of these capabilities that the House version asked for. It doesn't include the information on

the phasing of planned intermediate destinations, Mars, mission risk areas and the potential risk mitigation approaches that required by the bill offered by Ms. Edwards, and it does not include a description of the utility of an expanded human presence in cislunar space toward enabling missions to various lunar orbits, the lunar surfaces, asteroids, the Mars system and other destinations of interest.

So until the Administration provides the detailed information on the Asteroid Retrieval Mission including how it fits into a broader exploration architecture, I assume Congress is going to continue to view some of this project skeptically, which brings me to the question: NASA's budget request includes $180 million for the Asteroid Redirect Mission, so last year at the budget hearing, I wasn't here but I have been informed that you told the Committee that a mission formulation review would be done over the summer, but now it has been a year since the mission was announced. NASA has not completed the mission formulation review, and what I was told is, just last week you released a broad agency announcement for information and held an open forum yesterday to solicit even more input. So when is NASA going to actually have a plan for the mission that the Committee can review and how can you be sure that the mission is in fact a steppingstone to Mars, as the BAA claims, without a human exploration roadmap?

General BOLDEN. My estimate would be that over the next year we will continue to refine the concept for the Asteroid Redirect Mission. There are two big potential ways that we could do it right now, and that is what we are evaluating. That is the reason we continue to go to the community, industry, academia and entrepreneurs, to be quite honest, trying to determine whether we want to use a small asteroid—smaller—small is a relative term, where we grasp the asteroid and fly along with it and thrust against it or whether we go to a large asteroid, take a large boulder from it so that has to be determined, and that will determine the specifics of the mission, what type vehicle you use and everything.

We know that no matter what we do, we are going to need solar electric propulsion so we have identified that as, if you will, a hurdle to being able to do an Asteroid Redirect Mission, also a hurdle to getting to Mars because we know that is what we are going to use for cargo.

Mr. COLLINS. Well, you know, in the tough budget environment we are in, clearly I would say the more information that you can provide to Congress, the more likely you can get buy-in, and if things start to slip or commitments are made and not met, I think you can understand that is viewed problematically, and again, what I was told was yesterday when NASA presented to the scientific community, it was the opinion of some that the information that was presented was a broader set of data and information than has already been shared with this Committee or with Congress. So, you know, in priority setting, I guess I would just simply encourage NASA to give us more data than we ask for so that, you know, we are not feeling as though we are left out of the loop or that we are not important because you can understand the result if that is the feeling, which I think it is somewhat.

General BOLDEN. I appreciate and intend to respond to that request, and I would hope—I look at the staff in the back. I am told that we have been regularly briefing the staff on the progress with the Asteroid Redirect Mission, so if that is not true, somebody shake their head no, that is not true, and I will go back and——

Mr. COLLINS. I think the staff should be shaking their head no because clearly, as someone new to the Committee, very directly asked me to probe this because they don't feel like it has been so, so there is a——

General BOLDEN. Have they not been getting any information or not being getting sufficient information?

Mr. COLLINS. Well, not sufficient. If you are not getting sufficient information, you might as well not——

General BOLDEN. Robert Lightfoot, who is my Associate Administrator, usually does—he leads the team up here. If it is insufficient information, it is because we don't know. If it is no information, it is because I am being misled in thinking that they are coming——

Mr. COLLINS. Well, I don't think anyone would suggest it is no information but to some extent insufficient information means decisions can't be made.

General BOLDEN. It means we don't have enough information to make an informed decision. That is all it means.

Mr. COLLINS. Again, I would just encourage you, and I don't think it is saying anything to—the more information you can get this Committee, the more likely you will see the Committee——

General BOLDEN. Exactly, and I understand that, and again, I will go back to my comments earlier. There are big things happening. I would encourage people, part of getting ready for the Asteroid Redirect Mission is having a vehicle to take the crew. If you go to the Kennedy Space Center, you will see Orion. It is a spacecraft. It is not a drawing. It will fly next fall, this coming—before the end of the year. If you go to Michoud, you will see components of SLS that are under construction, whether they are barrel assemblies for the fuel tank or whether they are domes or whatever, that is real hardware. We are not talking about drawings anymore, and that is all a part of getting to the Asteroid Redirect Mission. So that may not be sufficient but that is all we have is hardware. If that is not sufficient, I don't know how to do better.

Mr. COLLINS. Thank you, General Bolden. My time is expired. Sorry, Mr. Chairman.

Chairman PALAZZO. That is fine. Great questions by all the Members of the Committee.

At this time, General, you are not going to get off without a second round of questions.

General BOLDEN. That is good.

Chairman PALAZZO. So I will open it up for myself, and this is similar to a follow-up on Commercial Crew.

Last year, the Associate Administrator, Bill Gerstenmaier, said basically 90 percent of all the development costs for the Commercial Crew is being paid for by the American taxpayer, and we know that the Commercial Crew contract is going to be similar to what the cargo was, anywhere from $7 to $11 billion or greater. So we are just thinking—you mentioned that if we don't—if you don't get the funding, that the schedule will slip beyond 2017. Is there any-

thing that NASA can actually do to entice these companies to actually put more skin into the game, perhaps? Yes or no.

General BOLDEN. I am confused by a number you just gave. Our total expenditure, unless my charts are wrong, the total expenditure on COTS over the five years that I have been the NASA administrator from the taxpayer was, we were appropriated $782 million and we obligated $780 million.

Chairman PALAZZO. Yeah, I am not talking about Commercial Crew.

General BOLDEN. Commercial Crew——

Chairman PALAZZO. I am talking about the value of the contracts that, you know, these companies are going to receive from $7 to $11 million, estimated value for flying, you know, cargo and crew. So I am saying, you know, we are basically paying 90 percent of the development cost. Is there a way to get them to maybe put more money into the program?

General BOLDEN. They do. That is the reason—that is why I mentioned earlier, when you said how have we managed to stay on cost, on target, on schedule, if you haven't given us what we asked for, it is because the companies have paid more than they would have normally paid. That is the only way they can produce hardware. We only paid them what we had. So—and I would have to go back—I will take for the record to verify the 90 percent number. I would be surprised if we are paying 90 percent of the cost of Commercial Crew development to this date. I would be really surprised.

Chairman PALAZZO. I mean, that is from a hearing we had September 14, 2012.

General BOLDEN. And I am told the information is proprietary, but I will go back and—I will take that for the record.

Chairman PALAZZO. Okay. At this time I recognize the Ranking Member.

Ms. EDWARDS. Thanks. Just very quickly, I do want to follow this up because earlier when you mentioned—I thought you had misspoken that the industry participants of the Commercial Crew program were providing more money than NASA. That doesn't seem to be the information that we have. So is it possible for you to provide the Committee with the amounts that each of the—even at some level, the amounts that each of the industry participants is putting in and NASA so that we can see that? Because otherwise I think all of us are under the impression that NASA, that the taxpayers are actually providing the bulk of the support for Commercial Crew. Is that wrong?

General BOLDEN. As I said, I will take that for the record.

Ms. EDWARDS. Okay. Thank you. And then you also—I mean, you can hear that—don't think we have coordinated our questions for you but what you can hear is a concern around the Asteroid Retrieval Mission, and so I wonder if you would be prepared by a date certain to provide the Committee with a roadmap and the analysis of the various options that there would be testing different kinds of technology for this plan to Mars, and so some of us, for example, have thought, well, maybe the Moon makes sense as a sort of test bed, others, the ISS, and others, the Asteroid Retrieval Mission, or maybe some combination, but when would you be able to provide

a roadmap with the analysis comparing these options and the technologies that would be derived to the Committee?

General BOLDEN. Congresswoman, I will go back. It was my impression, because I keep referring to it every time I come forward, we have two matrices. One shows human ratings, human performance, human concerns. The other one shows technology gaps. And we have had that—I look at that—I have been looking at it for a couple of years. I thought we made that available to the Committee-which shows these are things that we are accomplishing on the International Space Station, these are things that we will accomplish with the Asteroid Redirect Mission. But I will take that for the record and go back and make sure we have shared those matrices with your staffs and with you.

Ms. EDWARDS. And then what about lunar—so here is what we are wrestling with here. We have some different ideas on this Committee about what makes sense, but if you all aren't providing us with a real roadmap that outlines the technologies and then maybe says here is our scientific analysis about why this doesn't make sense or the other, it would help us to make a more informed decision from a budget perspective and from an authorizing perspective of what it is that we need to look at, and I think that the questions that you have heard on the Committee go to that point. I mean, it would help the Chairman and I very much to have that in hand, and it would help for you to say here is a date certain by which NASA can give that to us. I want to incorporate that date, quite frankly, if we are to do an authorization because then we can come back and evaluate what makes sense going forward and that deeply impacts budget. And don't leave the Moon out because you can hear the concern here on the Committee.

General BOLDEN. We won't leave the Moon out but——

Ms. EDWARDS. I am not saying that is where I am personally but it is a concern of the Committee.

General BOLDEN. Well, but I am just saying that we—you know, I can state with certainty the reason the Moon, we don't talk about it, is because there is no technological advantage to go to the Moon. There is no challenge technologically to go to the lunar surface.

Ms. EDWARDS. Well——

General BOLDEN. Except money.

Ms. EDWARDS. Okay. So in providing something to this Committee, it would be very helpful to have that analysis, to have the scientific, you know, sort of basis for that decision and also to have the buy-in collectively from the community about a direction. Because I think if we had that, we would make some very important decisions about in what direction we need to go.

General BOLDEN. We will attempt to do that. I have to caution, hoping that the community, whichever community you are talking about, if you are talking about the science community, hopefully buy-in is not all will agree. That will never happen.

Ms. EDWARDS. Okay.

General BOLDEN. There is the lunar community, and they are not in favor of anything—now we are talking about ideologues, so there is a community——

Ms. EDWARDS. Just give us an analysis, and then let us know who is for and against, an analysis that will help us in our deci-

sion-making so that what you want and what NASA needs is for this Committee all to be on the same page about the direction. That will help you as well as it will help us. Thank you.

General BOLDEN. I will take that.

Chairman PALAZZO. I now recognize the gentleman from Alabama, Mr. Brooks.

Mr. BROOKS. Thank you, Mr. Chairman.

Mr. Administrator, back to the issue with Russia and our ability to get to the International Space Station. What would be the consequences to the operational capabilities of the Space Station if within the next year Russia chooses to deny us access by no longer allowing us to hitch a ride on their rockets?

General BOLDEN. As I mentioned before, because we provide navigation, communications, power, and as I responded to somebody else, Station would probably—and I hate to deal in conjecture—the partners would probably have to shut the Space Station down.

Mr. BROOKS. And if the Space Station——

General BOLDEN. If you are thinking that the Russians will continue to operate the International Space Station, it can't be done.

Mr. BROOKS. And if the Space Station is shut down for an extended period of time, say——

General BOLDEN. I will not need—I will come to this—I will go to the President and recommend that we terminate SLS and Orion because without the International Space Station, I have no vehicle to do the medical tests, the technology development, and we are fooling everybody that we can go to deep space if the International Space Station is not there. That is the reason that we and Roscosmos and ESA and JAXA, everyone agree that hey, no matter what else is going on the surface of Earth, if we want to do this global exploration roadmap to which 12 different nations signed up, we have to have the International Space Station. That is the reason that the President said okay, I will agree to extend it to 2024 and we are going—I mean, you know, I don't want anyone to think that I need an SLS or Orion if I don't have the International Space Station.

Mr. BROOKS. Let me make sure I understand the sequence of events of your testimony.

General BOLDEN. Very plainly——

Mr. BROOKS. Let me make sure I understand the sequence of events from your testimony, and you correct me if I err. If the Russians deny us access to the International Space Station, it is your testimony that because of what services we provide to the International Space Station, you would have to shut it down, and if the International Space Station is shut down, you in turn would then see no reason to have the Space Launch System or Orion? So is it fair for me to infer that you would then recommend that those programs be shut down too?

General BOLDEN. And I need to correct what I said, if I said it. I don't know that the Russians denying us access—you are assuming that they come today and say okay, you are not going anymore and we are not going to bring your crew home so figure out how to get them home. I don't think that any of those contingencies are going to happen.

Mr. BROOKS. Well, I understand that there are probabilities that are involved.

General BOLDEN. But that supposition was given to me, and I don't accept that as a viable supposition.

Mr. BROOKS. I am one of those that believes in planning for all contingencies. It is much like the effort to acquire an asteroid.

General BOLDEN. We didn't plan on——

Mr. BROOKS. I don't think that the odds of an asteroid hitting us in the next few years are very big, but nonetheless, to me, that is an interesting mission because of the risk associated with one eventually hitting Earth and our having the capability of being able to thwart that. Granted, the Russians may not, over the next couple of years, shut us off from access to the International Space Station and all they have to do is deny us the ride that we keep thumbing with them, which if they are willing to attack other nations, it doesn't seem beyond the realm of possibility that they also might be willing to deny American astronauts rides to the International Space Station.

But having said that, if the International Space Station is shut down for any extended period of time, can it be resuscitated?

General BOLDEN. I will take that for the record. You know, anything can be done. You are asking for suppositions, Congressman Brooks, and——

Mr. BROOKS. No, I am asking for your expertise and insight on that subject.

General BOLDEN. I am not an expert on the environmental control and life support system of the International Space Station. So I said I will take that for the record——

Mr. BROOKS. All right. Thank you.

General BOLDEN. I mean, there is no either/or in terms of SLS and Orion and Commercial Crew, and I don't know how many ways to say that.

Mr. BROOKS. Right.

General BOLDEN. I know there are a lot of you who——

Mr. BROOKS. Thank you. You have answered my question.

General BOLDEN. Bear with me. You asked me——

Mr. BROOKS. If the Chairman would give me another minute in order to ask one other question?

General BOLDEN. This is the last thing I will say: if I don't have Commercial Crew and I can't get to low-Earth orbit, I don't need SLS and Orion. I showed you the exploration roadmap. If I can't get to low-Earth orbit, there is no exploration program.

Mr. BROOKS. All right. If I could go to my final question then. There was a study done entitled "Human and Nature Dynamics: Modeling Inequality and Use of Resources on the Collapse and Sustainability of Societies," and it concluded in part that income inequality contributes to the collapse of societies. It has come to my attention that the study also states, "This work was partially funded through NASA/GSFC Grant NNX12AD03A" and that NASA contributed $26,000 to a study on income inequality or that involved income inequality. Why is NASA spending money that should be related to space exploration, at least in my view, on income inequality issues?

General BOLDEN. NASA did not request such study. We did not endorse such study. We have not reviewed such study. The study was done at the University of Maryland as an offshoot of a study we did request on another subject. We don't control what a principal investigator chooses to do if they can get additional studies.

Mr. BROOKS. But it is your money. It is $26,000 of NASA funding. Are you telling me that NASA doesn't control what its money is being spent on?

General BOLDEN. An investigator performs the study that we request, and if they choose to amplify the study with additional information or additional data for their own use, we don't prohibit them from doing that.

Mr. BROOKS. Thank you for sharing that information.

General BOLDEN. It is not a NASA study, neither endorsed nor requested by us.

Mr. BROOKS. But paid for by NASA in part.

Chairman PALAZZO. Time is expired.

At this time I want to ask unanimous consent to enter into the record a letter—oh, I am so sorry. At this time I recognize the gentlewoman from Oregon, Ms. Bonamici.

Ms. BONAMICI. Thank you, Mr. Chairman, and thank you, Administrator Bolden, for staying for a second round of questions.

I wanted to follow up on the international partnerships and international cooperation, which we have talked about a lot in this Subcommittee, and we all appreciate the importance of it, and we have had some discussions about that this morning, but what I wanted to talk about is in light of the proposal to shut down SOFIA, what are the risks of the international partners coming to view NASA as an unreliable partner, for example? What has been the response of the international community when they found out about the SOFIA proposal?

General BOLDEN. The only members of the international community concerned about SOFIA so far have been the Germans, because that is our principal partner there, and before we announced the budget, Dr. Jan Verner and I had a long telephone conversation, and that is where we decided that we would set up a cochaired working group to look at options for SOFIA, and that is what I referred to earlier. A final decision on SOFIA has not been made because we don't know what the 2015 budget is going to say. But as Congressman Brooks says, we are planning for the contingency that we don't get additional money in the science budget for SOFIA, and that would mean that we would then have to phase out of the—put it in mothballs.

Ms. BONAMICI. Well, and to follow up on that, even though Germany may be directly the only partner that has expressed concern, what kind of message does that send to the rest of the international community, and have you heard any response from others about questioning why this might happen?

General BOLDEN. A good example would be ExoMars, which everyone was up in arms when we announced that we were having to step back from the initial agreements on ExoMars. When NASA entered into an agreement with the European Space Agency on ExoMars, times were better. We were going to provide launch vehicles for the 2016 mission, the 2018 mission. When the 2013 budget

was about to come out, I talked to the European partners and I said look—we had teams in Paris. This was leading into Christmas. I said this doesn't make sense. We have teams working on all this stuff, and I don't know what the 2013 budget is going to be. I cannot in good conscience allow the teams to keep working towards something that we may not be able to support. I said give us time, let us look at the budget and then we will determine what happens. When the 2013 budget came out, we found out we couldn't provide the launch vehicles that we had earlier promised. They went and negotiated and Russia as a partner in ExoMars agreed that they would do that. We agreed that we could hold up our end of the bargain on a communications package for 2016, and a very important scientific package on 2018. So the partners understood where we were. They go through the same thing. It is just that when they back out of something or they don't make a payment, it doesn't make the front page of the New York Times the way it does when the United States does it.

Ms. BONAMICI. Thank you, and I asked you earlier about Earth science. I want to ask you a question about planetary science. Can you talk a little bit about the continued cuts being proposed for NASA's Planetary Science program and whether that is consistent in light of the work that NASA plans to undertake on a Mars 2020 rover? How can the cuts to the Planetary Science program be consistent?

General BOLDEN. We are holding to a Planetary Science portfolio that we have brought to this Committee and others for a long time. Mars 2020 is still on track. We have to find ways, innovative ways to do missions when budgets are reduced, and our budget has been constantly reduced over time. As I said, the President requested a certain amount since I have been the NASA Administrator, and the amount appropriated has always been less than that was requested, and that is forgotten by most people. We have taken the resulting appropriations and we have figured out alternative ways to do things. Sometimes you descope a mission, sometimes you have to cancel it, but we have really canceled very few missions in the time that I have been the NASA Administrator because we have been able to find alternatives to how to do it.

Ms. BONAMICI. Thank you. And even though that may be forgotten by most people, I doubt that it is forgotten by people on this Subcommittee.

So thank you very much, Mr. Chairman. I yield back the balance of my time.

Chairman PALAZZO. The gentlewoman yields back.

At this time I ask unanimous consent to enter into the record a letter from the Planetary Society that has been shared with the minority ahead of time. Hearing no objection.

[The information appears in Appendix II]

Chairman PALAZZO. I

General BOLDEN. Mr. Chairman, may I get a copy of the letter, or can you remind me or refresh my memory of what it is? Because I get all kinds of stuff——

Chairman PALAZZO. You don't get the right to see it.

General BOLDEN. I don't get to see it? Okay.

Chairman PALAZZO. We will get you a copy of the letter, of course, and the attachment.

So at this time——

General BOLDEN. Is it good or bad? Can you give me a hint?

Chairman PALAZZO. Both.

General BOLDEN. Both?

Chairman PALAZZO. Yeah.

General BOLDEN. They want more money for Mars, and do they like Europa?

Chairman PALAZZO. General Bolden, thank you. Thank you for your valuable testimony and the Members for their questions. The Members of the Committee may have additional questions for you, and we will ask you to respond to those in writing. The record will remain open for two weeks for additional comments and written questions from Members.

The witness is excused, and this hearing is adjourned.

[Whereupon, at 10:57 a.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by The Hon. Charles F. Bolden, Jr.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE

"An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2015"

Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Rep. Steven Palazzo, Chairman, Subcommittee on Space

QUESTION 1:

NASA has consistently requested more funding for the Commercial Crew Program than the program has subsequently received.[1] Two years ago, you testified to this Committee that the FY 2013 request would put NASA "on track" for a commercial crew capability by 2017.[2] The actual appropriation for FY 2013 was $305M less than the request. One year ago, you testified to this Subcommittee that full funding of the FY 2014 request was "essential" to enabling Commercial Crew access to the International Space Station by 2017.[3] The actual appropriation for FY 2014 was $125M less than the request. The FY 2015 NASA budget justification states that 2017 is still the target date for a Commercial Crew capability.

QUESTION 1a:

The Administration is requesting $848M for Commercial Crew in FY 2015. If Congress appropriated more or less than this amount, how would that affect the target date? Is there a rule of thumb for converting dollar amounts into months of schedule?

ANSWER 1a:

There is no rule of thumb for converting dollar amounts into months of schedule. Additional funding, as proposed in the Opportunity, Growth, and Security Initiative, would help buy down programmatic risk and enable investments in testing and analysis. Such efforts would reduce the risk that a certified crew transportation capability would not be available in 2017. In the event NASA does not receive the base funding level of $848M requested in the President's FY 2015 budget, the Agency would have to look at schedule adjustments to the program.

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[1] FY 2011 request: $500M. FY2011 actual: $307M. FY2012request: $850M. FY 2012 actual: $392M. FY 2013 request: $830M. FY 2013 actual: $525M. FY 2014 request: $821M. FY 2014 actual: $696M.

[2] Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration, statement before the House Committee on Science, Space, and Technology, March 7, 2012.

[3] Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration, statement before the House Committee on Science, Technology, and Space; Subcommittee on Space, April 24, 2013.

As contract performance proceeds over the next several months, NASA will be able to use the fixed price contract values to assist in explaining the program budget and options for the rest of the contract. The details will be presented in the FY 2016 President's Budget Request.

QUESTION 2:

In briefing documents for the Opportunity, Growth, and Security Initiative (OGSI), available on the agency's website, NASA claims that an additional $250M, for the Commercial Crew Program would help to buy down programmatic risk. Specifically the program would use the funding to "enable early investments in necessary testing and analysis, which, along with competition, will be important for astronaut safety as this crew transportation system is being developed."

QUESTION 2a:

Absent the funding from this initiative, how will NASA handle the increased risk?

ANSWER 2a:

Absent the additional OGSI funding, NASA would reassess its out-year funding requests for the Commercial Crew Program to ensure an appropriate risk posture for the program.

QUESTION 2b:

How would NASA mitigate these risks absent additional funding? Is there a plan in place to mitigate these risks if the funding does not materialize?

ANSWER 2b:

Absent the additional OGSI funding, NASA would reassess its out-year funding requests for the Commercial Crew Program to ensure an appropriate risk posture for the program.

QUESTION 2c:

What is the process for determining which risks must be mitigated by this funding and which can be tolerated without the funding?

ANSWER 2c:

The Commercial Crew Program has a formal, robust, and documented risk management process. Risks are continually reviewed by the technical experts and program management and funds are applied to those risks when and as needed.

QUESTION 3:

NASA has requested $250M, in the OGSI for Commercial Crew. If NASA were to get these funds, could the commercial partners be ready to deliver crew to the ISS sooner than 2017 and what is the basis for your conclusion either way? Would any amount of additional funding shorten the schedule?

ANSWER 3:

If NASA were to receive the $250M in OGSI for Commercial Crew, the funding will be used to ensure development of a safe system in the planned schedule. However, it is important to note that there is no rule of thumb for converting dollar amounts into months of schedule, and so no guarantee that this level of funding would shorten the schedule. Additional funding would help buy down programmatic risk and enable early investments in necessary testing and analysis.

QUESTION 4:

To enable human exploration beyond Earth orbit, the NASA Authorization Act of 2010 directed NASA to develop the Orion crew vehicle and the Space Launch System (SLS).[4] The development of these systems is managed by a NASA program called Exploration Systems Development. Congress has consistently provided more funding for Exploration Systems Development than NASA has requested.[5] This was true even in FY 2013, despite reductions due to sequestration.

QUESTION 4a:

The first test flight of Orion and SLS without a crew, known as EM-1, was formerly expected in 2017. The FY 2015 budget justification now describes the target date as FY 2018. What factors caused this delay? What is the confidence level for the new date?

ANSWER 4a:

The FY2015 budget justification uses conservative language that takes into account both potential technical risks as well as budget uncertainty. The SLS program continues to work toward a readiness date of December 2017 to support EM-1, and is presently carrying five months of schedule margin to that date.

In August 2014, NASA announced the completion of SLS Key Decision Point-C (KDP-C), which provides a development cost baseline for the 70-metric ton version of the SLS of $7.021B from February 2014 through the first launch and a launch readiness schedule based on an initial SLS flight no later than November 2018.

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[4] P.L. 111-267. Sections 302 and 303.

[5] FY 2012 request: $2.810B. FY 2012 actual: $3.002B. FY2013 request: $2.769B. FY 2013 actual: $2.884B. FY 2014 request: $2.730B. FY 2014 actual: $3.115B.

NASA's commitment to SLS was based on an analysis at the 70 percent confidence level. This is consistent with both standard NASA policy and the recent GAO review of SLS, which recommended NASA set a commitment at the 70 percent confidence level.

Conservative cost and schedule commitments outlined in the KDP-C align the SLS program with program management best practices that account for potential technical risks and budgetary uncertainty beyond the program's control.

The Orion program continues to work to implement the EM-1 plan in FY 2018. Orion program detail planning to meet the EM-1 flight date is informed by EFT-1 development experience that will culminate in the first orbital exploration flight test in December 2014.

QUESTION 4b:

The first flight of Orion and SLS with a crew on board, known as EM-2, was formerly expected in FY2021. According to the FY 2015 budget justification, that date is now FY 2021-FY 2022. What factors caused this delay? What is the confidence level for the new date?

ANSWER 4b:

The FY 2015 budget justification uses conservative language that takes into account both potential technical risks as well as budget uncertainty. Both Orion and SLS planning and contract direction continue to plan for FY 2021.

QUESTION 4c:

Between FY 2012 and FY 2014, NASA received a total of $692M more than it requested for Exploration Systems Development. Why did additional funding lead to delays, particularly when you testified last year that if you had more money for SLS and Orion that it wouldn't help?

ANSWER 4c:

The FY2015 budget justification uses conservative language that takes into account both potential technical risks as well as budget uncertainty. The SLS program continues to work toward a readiness date of December 2017 to support EM-1, and is presently carrying five months of schedule margin to that date.

In August 2014, NASA announced the completion of SLS Key Decision Point-C (KDP-C), which provides a development cost baseline for the 70-metric ton version of the SLS of $7.021B from February 2014 through the first launch and a launch readiness schedule based on an initial SLS flight no later than November 2018. NASA's commitment to SLS was based on an analysis at the 70 percent confidence level. This is consistent with both standard NASA policy and the recent GAO review of SLS, which recommended NASA set a commitment at the 70 percent

confidence level.

Conservative cost and schedule commitments outlined in the KDP-C align the SLS program with program management best practices that account for potential technical risks and budgetary uncertainty beyond the program's control.

The Orion program continues to work to implement the EM-1 plan in FY 2018. Orion program detail planning to meet the EM-1 flight date is informed by EFT-1 development experience that will culminate in the first orbital exploration flight test in December 2014.

The FY 2015 budget justification uses conservative language that takes into account both potential technical risks as well as budget uncertainty. Both Orion and SLS planning and contract direction continue to plan for FY 2021.

QUESTION 5:

Following the first crewed flight of Orion and SLS, additional flights are expected to occur approximately once every two years. Last year, the Chairman of the NASA Advisory Council testified that the low flight rate projected for SLS and Orion is a serious problem. No human-rated launch system in NASA's history has flown so infrequently. With such a low launch rate it will not just be difficult to maintain program momentum; it will be difficult to keep flight teams sharp and mission-ready.[6]

QUESTION 5a:

What is NASA doing to address these concerns?

ANSWER 5a:

The programs look forward to being mission ready after EM-2. The projected flight rate is not typical of NASA's experience; however, we are designing the systems with this constraint in mind. SLS and Ground Systems Development and Operations (GSDO) is executing for a flight rate surge capability of up to two per a year to support missions up to and including crewed flights to Mars. As the programs continue to evolve efficiencies are being sought to ensure that new elements of exploration can be started, and additional flights flown, given modest increases to the exploration budget as provided in the President's budget request. In addition, NASA is investing in the Kennedy Space Center to create a multi-user capability that is not solely dependent on Exploration Systems launches. These investments are anticipated to bring multiple customers on site and further exercise critical KSC processing and launch capabilities. SLS is designed for the express purpose of enabling human exploration beyond low-Earth orbit in support of national objectives and policy. In addition, consistent with existing law and policy, SLS will not compete with launch services provided by

[6] Steven W. Squyres, Goldwin Smith Professor of Astronomy, Cornell University, testimony before the House Committee on Science, Space, and Technology, June 19, 2013

commercial activities, but is potentially available to support other national priorities that may require SLS-unique capabilities.

The Orion program also expects its current manufacturing capacity will support a greater launch rate. Orion is already working with the industry suppliers at all levels to find procurement approaches that level production resource demands consistent with the appropriated budgets, while maintaining the essential experience to fly missions safely.

QUESTION 5b:

What flight rate for SLS and Orion would you consider optimal, based on safety, maximizing the return on NASA's development investments, or other criteria? What data do you have to backup this optimal flight rate?

ANSWER 5b:

The current NASA baseline is for the first launch of the 70 metric ton capability SLS on EM-1 (an uncrewed mission) in FY 2018. The second launch, EM-2 (a crewed mission), is targeted for FY 2021. NASA is reviewing the post-EM-2 flight rate for SLS/Orion. We are currently identifying follow-on missions as part of achieving the goal of safely putting humans on Mars. NASA is also evaluating the next steps beyond the initial crewed mission on Orion, which includes the Asteroid Redirect Mission, to achieve the ultimate goal of pioneering Mars.

QUESTION 5c:

What would it take to achieve that optimal flight rate, in terms of funding or other factors?

ANSWER 5c:

Please see response to Question #5B, above. The President's FY 2015 budget request supports a sustainable program for near-term human exploration of deep space.

It is difficult to project what funding would be required for yet undefined missions that are beyond the current budget horizon. NASA is evaluating the next steps beyond the initial crewed mission on Orion, which includes the Asteroid Redirect Mission, to achieve the ultimate goal of pioneering Mars.

QUESTION 6:

Under NASA's planned Asteroid Redirect Mission, the first crewed mission for Orion/SLS will be to an asteroid that has been redirected into orbit around the Moon.

QUESTION 6a:

What work is NASA doing to define options for subsequent Orion/SLS missions?

ANSWER 6a:

NASA continues to refine mission architecture and the evolution plans. For example, SLS evolution, 105mt, then 130mt, is tied to mission requirements.

The series of missions NASA has planned in the "proving ground" of cis-lunar space follow a sustainable approach to developing the capabilities required to get humans to Mars. Using current candidate asteroids, the robotic spacecraft for the Asteroid Redirect Mission could provide substantial asteroid mass in the lunar vicinity for astronaut exploration and sampling on the ARM mission of SLS and Orion. NASA's plan is for this crewed mission to encompass 26-28 days, including 5 days in the stable lunar distant retrograde orbit for Orion rendezvous and docking with the ARM robotic spacecraft and attached asteroid mass and implement the astronauts' extra-vehicular activity.

NASA is defining mission objectives of EM-2 (first crewed mission of Orion) and EM-3, including systems test and demonstration, and risk reduction for the ARM crewed mission and future missions to Mars moons, Mars orbit, and Mars surface.

Mission options to follow ARM include further use of the advanced solar electric propulsion bus used for ARM; addition of a potential deep space habitat; additional potential return missions to the asteroid for expanded science and/or resource utilization; support for commercial and/or international missions in the lunar vicinity; and/or beginning mission trajectories to Mars vicinity.

Proposed plans are responsive to NASA Human Exploration and Operations' strategic principles for exploration implementation:

1. Implementable in the ***near-term with the buying power of current budgets*** and in the longer term with budgets commensurate with economic growth;
2. Application of ***high Technology Readiness Level*** (TRL) technologies for near term missions, while focusing sustained investments on technologies and capabilities to address challenges of future missions;
3. ***Near-term mission*** opportunities with a defined cadence of compelling human and robotic missions providing for an incremental buildup of capabilities for more complex missions over time;
4. Opportunities for ***US commercial business*** to further enhance the experience and business base learned from the ISS logistics and crew market;
5. ***Multi-use, evolvable*** space infrastructure; and,
6. Significant ***international and commercial participation***, leveraging current International Space Station partnerships.

NASA mission options for the Proving Ground of the lunar vicinity are intended to build and demonstrate the capabilities for missions to the Mars system. Key examples of approach include the use of advanced solar electric propulsion and deep space habitation. This modular approach is also open to international

participation whereby our partners can leverage the capabilities and build on it to share cost and increase utilization and return.

QUESTION 6b:

How soon will NASA need to make a decision regarding the next Orion/SLS destination, following the Asteroid Redirect Mission?

ANSWER 6b:

NASA is evaluating the next steps beyond the initial crewed mission on Orion, which includes the Asteroid Redirect Mission, to achieve the ultimate goal of pioneering Mars.

QUESTION 6c:
There is a widespread view that human exploration of Mars should be the eventual goal, even if there are several intermediate, less challenging goals. Is it realistic to contemplate human exploration of Mars at the current level of NASA's budget? If not, how much more funding would be needed, at some future time, to meet the ultimate goal of a manned mission to Mars?

ANSWER 6c:

NASA has a goal of sending a human mission to Mars in the 2030s. The President's FY 2015 budget request funds development of systems for near-term human exploration of deep space destinations, including to a redirected asteroid in a distant retrograde orbit around the Moon. The specific funding levels for future missions will depend on factors including the incremental development of hardware like SLS and Orion, as well as other assets to support humans in deep space, such as a potential habitation module. It will also depend on partnering opportunities, the ability to leverage technology developments, the ability to leverage possible extant resources, as well as learning about the human ability to live and work longer in deep space (including lessons learned from ISS). As NASA learns from initial missions using SLS and Orion, the Agency will formulate cost and schedule details of future goals and hardware, and this analysis will be reflected in future budget requests.

QUESTION 7:

The Administration's request includes a reduction of $360M for the Space Launch System and the Orion. You have testified in the past that if NASA does not need any more money that has been requested to meet all schedule and technical requirements. Yet, this year the Administration requested $100M more as part of the OGSI.

QUESTION 7a:

Given the request for additional funds, do you now believe there is more that can be done to meet the schedule and technical requirements for the SLS and Orion?

ANSWER 7a:

Should OGSI funding be made available, NASA would apply a portion to long-lead items to support the development of SLS and Orion. This would help reduce schedule risk.

QUESTION 7b:

What technical and program risks is NASA prepared to tolerate if the OGSI does not materialize?

ANSWER 7b:

Should OGSI funding not be made available, NASA would continue to work to the launch schedule of FY 2018 for EM-1 and FY 2021-2022 for EM-2 in accordance with the President's FY 2015 Budget Request. The schedule and technical margin would be less than it would if OGSI funding were received.

QUESTION 7c:

Are the risks you intend to buy down with these funds a lower priority than the asteroid mission given you have requested roughly similar amounts for each?

ANSWER 7c:

It is important to keep SLS, Orion, the ground systems that support them, and the various components of the Asteroid Redirect Mission (ARM) on track. One of the challenges for NASA is to balance its programs in such a way that all of the required assets come together on schedule to achieve mission success. The President's FY 2015 budget request enables this.

QUESTION 8:

Section 302 and 303 of the NASA Authorization Act of 2010 include minimum capability requirements for the SLS and Orion. Among those requirements is the ability to serve as a back up to deliver cargo and crew to the International Space Station.

QUESTION 8a:

Given the importance of securing United States crew launch to ISS, how is NASA meeting the 2010 Authorization Act requirement to keep the Orion crew capsule as a viable back up for the commercial providers?

ANSWER 8a:

NASA anticipates that commercial crew transportation services to ISS will be available in 2017. This is the fastest way to achieve crew transportation capability.

Commercial crew transportation services must meet less demanding technical requirements, and this allows commercial crew to be available soonest given appropriate funding. If this is not the case, and if Russian Soyuz services are also unavailable, NASA could potentially move the FY 2021-2022 date of the SLS/Orion crewed test flight forward with increased funding, fulfilling the back-up role of SLS/Orion; however, this would be a highly inefficient use of the Orion and the SLS. The SLS is a heavy lift launch vehicle and has payload capability far and above that which is necessary to support ISS crew rotation and resupply activities; therefore, launching an SLS for ISS-related activities would be a highly inefficient use of the system that is simply not cost-effective. In an emergency, the SLS could be used for Low Earth Orbit (LEO) operations. In addition, the Orion is a crew vehicle that is primarily designed for deep space exploration and, if needed for an emergency, could function as a backup vehicle for the International Space Station (ISS) crew. The current Orion design is specifically designed and tailored for deep space exploration and a high-speed reentry to Earth, which includes systems that are not necessary for LEO missions. Launching the Orion capsule for use in LEO would also be an inefficient use of a robust system intended for other purposes.

QUESTION 8b:

Does NASA have cost estimates for the modifications necessary to accomplish the back-up role?

a. If so, please provide these estimates.
b. If not, please conduct this analysis.

ANSWER 8b:

A rough estimate of the costs for this capability by FY 2021 are about $1.3B above the baseline estimate for a single mission to the ISS. The estimate includes the shifting of the first crewed flight test forward, EM-2 to 2019, and the development of a mission kit that provides ISS contingency docking capability in the event other vehicles are unable to perform the mission. No cost commitment is currently in place.

QUESTION 8c:

What is the required timing to implement Orion as a back up? If NASA does not have a notional schedule, please conduct this review and provide the results to the Committee.

ANSWER 8c:

Once a commitment to develop the required mission kit is in place, NASA could implement the use of Orion as a LEO back up in approximately 4-5 years.

QUESTION 8d:

Would NASA fly an Orion crew capsule that is fully capable of operating in deep space as a backup for ISS support, or could NASA use a less capable, more

tailored Orion that is more appropriate for a more limited ISS support role?

ANSWER 8d:

The mission kit for LEO operations would include the capability for docking at the ISS, but deep-space systems, such as the heat shield, would still be in place. As noted in the response to Question #8a, this would be a suboptimal use of Orion and re-scoping Orion for to support only an ISS mission would require additional funding and time to accomplish.

QUESTION 8e:

Do the cost and schedule estimates in (b) and (c) assume the full long duration deep space capabilities of Orion, or a more narrow capabilities package necessary to service ISS?

ANSWER 8e:

The mission kit for LEO operations would include the capability for docking at the ISS, but deep-space systems, such as the heat shield, would still be in place. As noted in the response to Question #8a, this would be a suboptimal use of Orion and re-scoping Orion for to support only an ISS mission would require additional funding and time to accomplish.

QUESTION 8f:

Given the recent world events, has NASA re-evaluated the options and cost for Orion to serve as a back up?

ANSWER 8f:

NASA has not re-evaluated the specifics of the Orion LEO mission kit option, life support system acceleration, and service module acceleration. Doing this work now would delay progress towards a deep space capable vehicle.

QUESTION 8g:

What does NASA see as the precipitating event? Would NASA consider the failure of a commercial launch a rationale to utilize the Orion crew capsule as a back up?

ANSWER 8g:

NASA is confident in the ability of U.S. industry to develop commercial crew transportation capability. In the event of a mishap, NASA managers would evaluate the situation, but there is no single "trigger event" that would necessarily cause the Agency to utilize Orion as a LEO back-up vehicle.

QUESTION 8h:

When will NASA be ready to use the Orion as a back up to the Commercial Crew Program should the development efforts take longer than expected?

ANSWER 8h:

Once a commitment to develop the required mission kit is in place, NASA could implement the use of Orion as a LEO back up in approximately 4-5 years.

QUESTION 9:

NASA has chosen to test the Orion capsule like a commercial data-buy under a contract rather than conducting the test itself. This has changed the dynamic between NASA and Air Force in scheduling launches. Recently it was announced that the Exploration Flight Test 1 would be delayed by three months due to the launch of a national security payload.

QUESTION 9a:

How does this newway of doing business affect NASA?

ANSWER 9a:

Exploration Flight Test-1 (EFT-1), an uncrewed, two-orbit, high apogee, high-energy-entry, low-inclination test mission that is targeted for flight later this year. The flight test will provide an opportunity to significantly inform critical design by operating the integrated spacecraft hardware and software in flight environments that cannot be duplicated by ground testing. Purchasing data from the vendor enables NASA to achieve cost savings that would not be realized if the Agency were to procure and launch the mission itself. The method used to acquire these data did not affect the launch schedule. NASA was consulted and the Agency agreed to the delay to December for benefit of the U.S. Government.

QUESTION 9b:

What types of extra costs are incurred as a result of these types of delays?

ANSWER 9b:

NASA is minimizing the cost by continuing to prepare the Orion crew module according to the original plan. Orion will be securely stored until the Launch Vehicle is ready for integration prior to the projected November/December 2014 launch.

QUESTION 9c:

How is NASA's negotiating position for launch slots on the range altered as a result of this type of arrangement?

ANSWER 9c:

NASA's negotiating position for launch slots on the range is not impacted by the fact that EFT-1 is a data purchase. For Exploration Flight Test 1 (EFT-1), NASA is not directly negotiating with the range; this is a commercial venture between United Space Alliance and Lockheed-Martin. However, NASA fully participates and is consulted in all of these discussions.

QUESTION 9d:

Is this a harbinger for potential conflicts in the future for the Commercial Crew Program?

ANSWER 9d:

No, conflicts for launch dates on the Eastern Range will be driven by the number of launches scheduled during a given year. The more crowded the manifest, the more likely there will be conflicts. The Commercial Crew Launch Service provider(s) is/are responsible for acquiring the required launch timeframe on the Eastern Range that meets the contractual requirements. NASA is also a full member in the Current Launch Schedule Review Board (CLSRB) process organized by the Air Force to allocate Range resources. To date, NASA has been able to work closely and successfully with the Air Force (as the Eastern Range operator) and the other members of the CLSRB (i.e., NRO and FAA), as well as with our launch service providers to deconflict resource issues and meet our launch needs. We expect the need to work closely as part of the CLSRB to continue for Commercial Crew missions.

QUESTION 10:

In regards to the Asteroid Redirect Mission, you stated in your testimony that, "Like the invaluable ISS, this mission will provide NASA with critical knowledge, experience, and technologies for future human exploration missions deeper into space." Without knowing what the mission will look like, what type of technologies will be developed, or even exactly what the specific mission architecture will look like, how can NASA assert that it will gain this experience?

QUESTION 10a:

Couldn't NASA better determine what technologies and mission architecture are needed if it had an integrated human exploration roadmap?

ANSWER 10a:

NASA has been executing an integrated human and robotic exploration strategy leading to the human exploration of Mars. The capabilities required for a human mission to Mars have been understood for some time. The implementation steps and investments, partner approaches, and technical pathways to Mars are varied.

NASA will ramp up its capabilities to reach – and operate at – a series of increasingly demanding targets, while advancing technological capabilities with each step forward. This will include early test and demonstration activities in cis-lunar space as called for in the NASA Authorization Act of 2010. The Agency is tightly coupling the planning of its science and technology portfolios with this strategy where appropriate.

QUESTION 10b:

What does NASA use to guide these types of decisions without such a roadmap?

ANSWER 10b:

NASA has been executing an integrated human and robotic exploration strategy leading to the human exploration of Mars. The capabilities required for a human mission to Mars have been understood for some time. The implementation steps and investments, partner approaches, and technical pathways to Mars are varied. NASA will ramp up its capabilities to reach – and operate at – a series of increasingly demanding targets, while advancing technological capabilities with each step forward. This will include early test and demonstration activities in cis-lunar space as called for in the NASA Authorization Act of 2010. The Agency is tightly coupling the planning of its science and technology portfolios with this strategy where appropriate.

QUESTION 11:

One of the main arguments for the Asteroid Retrieval Mission is that it provides skills and capabilities needed to send humans to Mars. In May of 2013, NASA Advisory Council Chairman, Dr. Steve Squyres, testified that "...to me the connection between particularly the Asteroid Retrieval Mission, which involved proximity operations with a rock that would fit comfortably into this hearing room, I see no obvious connection between that and any of the technologies or capabilities that are required for Martian exploration." Additionally, the Small Bodies Assessment Group, NASA's own advisory group focused on near Earth objects (NEO) found it "to be very interesting and entertaining" but that "it was not considered to be a serious proposal."

QUESTION 11a:

It has been over a year since Dr. Squyres testified on this topic. In that time NASA has still not provided a program office, budget, or timeline for this mission. What additional information can NASA provide to Congress to demonstrate that the Administration is working is working to provide answers to the many scientists and industry leaders that have expressed their concerns?

ANSWER 11a:

Since announcement of NASA's initiative, a strategy for Asteroid Redirect Mission (ARM) pre-formulation, which also comprehensively responded to early feedback,

is being implemented. This included additional study of technical and programmatic aspects of the reference mission concept to capture and redirect a single small Near Earth Asteroid (NEA) of 7-10 meter mean diameter by leveraging a planned solar electric propulsion (SEP) technology demonstration mission, and use of the Space Launch System and Orion multi-purpose crewed vehicle. Also included were trade studies of alternatives for the SEP system and capture mechanism. NASA initiated a detailed study of an alternative overall asteroid redirect mission concept to capture a large cohesive, boulder-like mass from a larger asteroid and redirect it to the same stable orbit around the Moon as studied in the reference concept. Multiple elements were included which also addressed findings from the Target NEO2 workshop held in July 2013 and feedback from the Small Bodies Assessment Group community, were employed.

Elements of NASA's approach in 2013 and early 2014 included the following:

- implementation of asteroid target identification plan;
- development and provision of a clear set of preliminary high level mission objectives;
- release of a broad Request for Information early in pre-formulation (June 2013), which drew over 400 responses;
- NASA senior leader review of concepts, trade studies, and a RFI response summary in a Mission Formulation Review in July 2013;
- transparent and public examination of the highest rated responses though an Ideas Synthesis workshop live streamed through the internet to support broad participation;
- detailed study of the alternate robotic mission concept; and,
- initiation of a Robotic Concept Integration Team, led by one of NASA's most senior systems engineers, to integrate the internal and external input.

In addition to external input through the Request for Information, the Robotic Concept Integration Team included assessments from the community through requests to the Small Bodies Assessment Group and Curation and Analysis Planning Team for Extra-terrestrial Materials. A status briefing to NASA senior leaders in December included a summary of progress against findings from the Target NEO2 workshop in July, and leaders from that workshop were invited to brief NASA's senior leaders personally on their findings to ensure the intent and context was understood. In addition, comprehensive study of the Asteroid Redirect Mission concept technologies and systems extensibility to crewed missions to Mars was undertaken.

In February 2014, NASA senior leadership reviewed the current asteroid findings of the reference and alternative robotic mission, status of the crewed mission concept, and findings of the Robotic Concept Integration Team. A subsequent letter was signed by the NASA Associate Administrator and Associate Administrators for Human Exploration and Operations, Science, and Space Technology, which detailed the resulting decisions and forward plan to continue mission pre-formulation. NASA continues to involve the external community in pre-formulation, most recently through the release of a Broad Agency Announcement and conduct of an Opportunities Forum in March 2014, and tasking

of a special action team from the Small Bodies Assessment Group. Many of the results of the extensibility analysis have been publicly discussed in exploration plans of the human path to Mars over the last several weeks.

NASA's ARM effort has evolved significantly in the last year, with further details developing as to how the mission relates – in terms of exploration and technology development – to the Agency's ongoing journey to Mars. NASA continues to refine its near-term exploration objectives in the proving ground beyond low Earth orbit; ARM will play a key role in this area.

QUESTION 11b:

How can NASA assess the value of a mission like this for future Mars exploration without a human exploration roadmap?

ANSWER 11b:

NASA, in partnership with twelve space agencies around the world, has developed a Global Exploration Roadmap (GER) to define a coordinated international strategy for deep space exploration. The GER demonstrates the important role of NASA's asteroid mission in advancing the capabilities needed for exploring Mars and the economic and societal benefits to humans on Earth that such exploration missions can bring about. This GER defines common goals for missions to the Moon, cis-lunar space, and Mars. There is common agreement among these agencies that cis-lunar space is the next best destination given the resources available in these countries to commit to space exploration.

The Asteroid Redirect Mission develops many of the building blocks required for missions to Mars including the Space Launch System, Orion, High Power SEP, Docking Systems, Rendezvous Sensors and Navigation in Deep Space, and the EVA Portable Life Support Systems that feed forward to the surface of Mars. The solar electric propulsion system including the advanced solar arrays for the robotic asteroid redirect spacecraft is deemed an essential component to deliver cargo for Mars missions, logistics and potentially the propulsive return stage to Mars orbit – efficiently and affordably preplacing these assets prior to the arrival of humans. Additionally, the mission involves complex trajectory operations including a flyby of the lunar surface at a distance of 100 km. Since NASA has each of these vehicles and systems in development today, the mission brings value by compiling the building blocks for Mars is unmatched by any other proposed early mission of SLS and Orion.

QUESTION 11c:

Has NASA done any studies to suggest the value of a mission like this for future human exploration efforts versus other missions, and if so, what was the process and who was involved?

ANSWER 11c:

Over the last two years, NASA has reviewed many potential missions in cis-lunar space to develop the capabilities required to expand human presence beyond low-Earth orbit to other regions of space, with the ultimate objective of international exploration of the Mars surface per the NASA Authorization Act of 2010.

Mission options were considered in the context of principles in which missions: are implementable in the near-term with the buying power of current budgets and in the longer term with budgets commensurate with economic growth; build multi-use, evolvable in space systems while being aligned with the Global Exploration Roadmap and interests of our International Partners which includes missions in the lunar vicinity; leverage on-going technology and systems development to build advanced capabilities, such as the Space Launch System and Orion; and support a continued U.S. government focus on research and technology to address challenges of future missions to Mars such as deep space habitation, human health and performance, advanced propulsion, and entry decent and landing. These strategic principles later evolved to NASA's Human Exploration and Operations "strategic principles for exploration implementation".

After this extensive assessment of numerous missions by space operations and human exploration experts, including decades of experience such as former Space Shuttle Flight Directors and Shuttle Program Managers, NASA determined that bringing an asteroid to cis-lunar space so that it could be sampled by astronauts, based out of Orion, offered the best compromise between remaining affordable, offering a compelling near-term mission utilizing our emerging exploration assets including SLS and Orion, and advancing our capabilities and experience as we head to Mars. The mission leverages the Space Technology Mission Directorate Solar Electric Propulsion technology including the advanced solar arrays that feed forward to delivering cargo and logistics to Mars. The mission advances EVA, the International Docking System Automated Rendezvous & Docking, and complex operations which all feed into future deep space and Mars exploration. We move forward toward missions to Mars as fast as possible, in the most affordable fashion, maximizing the use of all the ongoing exploration work in the agency.

As discussed in the response to Question 11a, NASA has been sharing the results over the last several weeks of comprehensive analysis of the extensibility of the Asteroid Redirect Mission within the Exploration Planning Human Path to Mars. This includes commercial and international opportunities, as discussed in the RFI released in June 2013, BAA released in March 2014, in the Global Exploration Roadmap, and most recent progress in the NASA Community Workshop on the Global Exploration Roadmap in April 2014.

QUESTION 12:

In the President's budget request for FY 2011, the Administration proposed to cancel the Constellation Program citing program delays and cost overruns. At that point in the development cycle, Constellation was projected to deliver crew by 2017, the current target of the Commercial Crew Program. This was the projected

launch date even after the Administration slashed the Constellation Program's budget. Has NASA done an analysis of this decision from a budgetary perspective to see if that was the right decision? Have we received any benefit from cancelling Constellation and beginning a whole new development program?

ANSWER 12:

While both SLS and Orion have benefitted from work conducted during the Constellation Program, as well as the Space Shuttle Program, NASA would not have been able to adequately fund the Constellation family of vehicles. Affordability and sustainability are key considerations of the Space Launch System (SLS) and Orion efforts – these programs reflect NASA's intent to develop vehicles with reduced operating cost, as evidenced by key design trades conducted that weigh potential production and operations costs against similar historical applications as key considerations.

QUESTION 13:

In 2011, NASA eliminated the longstanding waivers to Termination Liability requirements for the Constellation contracts. This change in policy led to a deficit in the Constellation program of nearly a billion dollars. Today, NASA is using a similar tactic with the SLS and Orion programs. There are some contracts under the Human Exploration and Operations Mission Directorate, such as ISS contracts, which utilize a "Special Termination Costs Clause" to manage termination liability and thus free up those funds for actual work on the contract. Why has NASA chosen not to continue the use of this clause on the prime contracts for SLS and Orion?

ANSWER 13:

NASA's policy for funding termination liability obligations has remained consistent for at least two decades. For nearly every incrementally funded contract, NASA manages termination liability by using standard Federal Acquisition Regulation (FAR) clauses (Limitation of Funds (LOF), FAR 52.232-22). These standard government-wide LOF clauses instruct contractors to consider any potential termination liability when notifying NASA when their anticipated costs approach the limit of an increment of funding.

In a few cases, NASA Program and Contract management personnel have elected to use a Special Termination Cost Clause (STCC), which allows contractors to exclude termination liability costs when calculating the anticipated date of reaching the limit of a funding increment. In the few cases NASA has used one of these clauses, NASA follows the direction given in multiple Comptroller General opinions that an Agency must obligate or reserve funds equal to the termination liability referenced in the STCC (*e.g.*, Comptroller General, *USAF B1-B Core Program*, B-238581 (1990), "In similar situations, we have held that the government has obligated the amount of the termination liability"). When NASA reserves these funds in accordance with this Comptroller General direction for the exclusive purpose of covering the STCC termination liability, the funds are no

longer available for contract performance.

This requirement to obligate funds derives from the Anti-Deficiency Act, and therefore is not subject to waiver by an agency alone. NASA has never purported to issue "waivers" for programs to use an STCC without making the corresponding obligation or reservation. NASA periodically reviews its programs to determine whether termination liability funding practices are consistent with the law, the FAR, and NASA guidance. When NASA has found discrepancies, we have taken appropriate remedial action. For example, in 2010 NASA discovered that certain contractors within the Constellation Program were not taking into account potential termination costs in accordance with the Limitation of Funds clause in their contracts. NASA formally reminded the contractors that NASA intended to enforce the Limitation of Funds clause in the event of a termination. NASA and the contractors re-phased the ongoing work on the contract, including potential termination costs within the total amounts obligated to the contracts *(see* Comptroller General, *Constellation II*, B-320091 (2010) at 7-10, for an extended discussion). At no point was NASA found to be "deficient" in the sense of obligating in excess of available appropriations; to the contrary, NASA's actions served to avoid a deficiency. *See* GAO, *A Glossary of Terms Used in the Federal Budget Process* (2005), at 43. For the two Constellation contracts that had STCCs (as distinct from the contracts using the Limitation of Funds Clause, discussed above), NASA was properly obligating funds for termination liability. There was no change in policy; rather, NASA acted to bring existing contracts into compliance with established policy.

Because of this obligation requirement, an STCC (without an explicit statutory exemption from the ADA) has limited and debatable budgetary benefits. The ADA and Comptroller General guidance require agencies to make a stand-alone reservation of budget authority corresponding to the specific amount cited in the contract as the maximum termination liability. If an agency follows this clear precedent, no additional funding is "freed up" for the program. In many cases, less funding may be available for contract performance because the standard Limitation of Funds clause has built-in flexibility for contractors as actual termination liability estimates change over time (usually trending downward), whereas the reservation required by an STCC is a relatively static amount. Additionally, in obligating the budget authority, NASA program managers incur additional administrative burdens, reduced flexibility in managing programmatic content, and increased risk of an ADA or other funds control violation. Finally, the Government is not in as good a position as a contractor to contain or accurately estimate potential termination costs ("The limitation of funds clause creates an incentive for contractors to accurately track both the costs of performance and any termination costs that they may incur." *Constellation II*, B-320091 (2010) at 9). It can be more likely under an STCC than under the standard Limitation of Funds clause that the government is forced to divert more money from contract performance than is actually required.

Specifically with regard to the ISS Prime contract, an STCC was negotiated into this contract in 1995 because NASA personnel at that time believed there was a statutory exemption from some ADA termination liability requirements in the FY

1994 appropriation. P.L. 103-124 stated, "Provided further, that of the funds provided under this heading, $1,946,000,000 is available only for the redesigned space station, of which (1) not to exceed $160,000,000 shall be for termination costs connected only with Space Station Freedom contracts." To whatever extent this proviso could be viewed as an implicit exemption from the ADA (the Comptroller General has almost never recognized "implicit" ADA exemptions), thereby enabling ISS program to obligate a maximum of $160M for termination liability even if actual potential termination liability estimates exceeded that amount, such an exemption would only have been in force for the duration of that appropriation through September 1995 (the language was not repeated in law, though conference reports in 1995, 1997, and 2006 contained similar language). After that period, because of the STCC, if funds obligated to the ISS contract dropped below an amount sufficient to cover both contract content and termination liability, NASA was at risk of violating the ADA. The clause was never negotiated out of the contract, and currently ISS Program and Finance managers follow ADA and Comptroller General requirements to estimate, track, and reserve funds corresponding to the ISS potential termination liability.

In light of this experience, we have not determined that the possible benefits of using an STCC on the SLS or MPCV/Orion contracts outweigh the potential budgetary drawbacks, significant administrative burden, and funds control risks associated with such clauses.

QUESTION 14:

The Administration has announced that it intends to extend the operation of the International Space Station (ISS) to at least 2024.

QUESTION 14a:

In the NASA Authorization Act of 2010, when Congress directed NASA to extend ISS operations to 2020, it mandated a comprehensive technical review of ISS components and systems, in order to identify any needs for spares or replacements. It also required NASA to report to Congress on the results of this assessment, and it required the Government Accountability Office to provide an evaluation of NASA's findings.[7] What comparable technical analysis does NASA plan to carry out to ensure that the extension to 2024 is effective and safe? How will the results of this analysis be communicated to Congress? What outside bodies will evaluate NASA's findings?

ANSWER 14a:

With the ISS extension to 2020, the ISS Program undertook a comprehensive technical assessment for Station extension. In the process of doing this assessment, analysis for extending the ISS operations to 2028 was also undertaken, in case further extensions past 2020 were to occur. A status of this ongoing assessment

[7] P.L. 111-267, Sec. 503.

was reported to the Congress in the ISS Sustainability Plan, which was called for in the FY 2014 Omnibus Appropriations Act (P.L. 113-76). A 2012 Government Accountability Office (GAO) audit (GAO-12-587T) found that NASA has a reasonable approach to meeting the challenge of estimating ISS spares and assessing Station's structural health and safety. In 2013, an independent Program Implementation Review examined ISS extension to 2020. In addition, the NASA Advisory Council (NAC) and Aerospace Safety Advisory Panel (ASAP) regularly review NASA's plans related to ISS, including the extension analysis. Finally, the NASA Office of Inspector General (O IG) and the GAO are currently conducting independent reviews of ISS sustainability beyond 2020. NASA has done similar analysis and can show full sustainability to 2024, pending some minor additional analysis.

QUESTION 14b:

In addition to technical and engineering analysis, what other steps are needed to enable the extension to 2024? What agreements will NASA need to negotiate with its international partners? What is the schedule for negotiating those agreements? What do you expect will be the most challenging issues to resolve?

ANSWER 14b:

NASA's international partners would have to consider the proposal according to their respective governmental decision making processes. Since the Intergovernmental Agreement and Memoranda of Understanding that govern the Partnership have no expiration date, no renegotiation would be required. NASA is confident that, should ISS operations be extended, the robust partnership currently in place would work to resolve any issues that might arise as we go forward.

QUESTION 14c:

The U.S. ISS components were designed for a 15-year lifetime, starting from a nominal reference date in February 2001.[8] Operation to 2024, rather than 2020, will thus be a second four-year extension. Would additional extensions beyond 2024 be possible? What are the advantages and disadvantages of additional extensions?

ANSWER 14c:

U.S.-built Station modules were designed for a 30-year on-orbit lifetime. The lifetime extension data that NASA and the ISS Partnership have reviewed to date indicates that extension to 2028 is technically feasible. In considering any option to further extend ISS beyond the proposed 2024 date, NASA would have to weigh the advantages likely to accrue from further scientific research and technology

[8] National Aeronautics and Space Administration, *NASA Report to Congress Regarding a Plan for the International Space Station National Laboratory,* May 2007, http://www.nasa.gov/pdf/181149main_ISS_National_Lab_Final_Report_rev2.pdf, p. 5.

development activities, plus further on-orbit operational experience, against other Agency priorities.

QUESTION 14d:

What are NASA's plans for safely deorbiting the ISS, when operations end? When the decision to end operations is made, how long will it take to implement those plans?

ANSWER 14d:

NASA continues to work with its ISS Partners on the deorbiting of Station once operations have concluded. The nominal plan would involve using a Russian Progress cargo ship to lower Station's orbit to the point where it re-enters the atmosphere. Once the vehicle is available, strategic planning for the deorbit – including configuration of the Station – would take place over approximately one year, with Station's orbit being allowed to decay naturally. Once the ISS' orbit has been lowered sufficiently, the propulsive phase and atmospheric entry would take place over a four-day period.

QUESTION 14e:

Assuming the United States has a domestic capability to access the ISS by 2020, what are the implications of Russia rejecting the United States' request to prolong the use of ISS beyond 2020?

ANSWER 14e:

Space cooperation has been a hallmark of US-Russia relations, including during the height of the Cold War, and most notably, in the past 13 consecutive years of continuous human presence on board the ISS. NASA has not received any official notification from the Government of Russia on any changes in our space cooperation at this point.

Currently, NASA is reliant on Roscosmos for crew transportation and rescue for the ISS. Beyond crew transportation and rescue, under the current ISS construct, NASA and Roscosmos are mutually reliant on one another for the life of the ISS. NASA will continue to need Russia-unique critical capabilities not currently available elsewhere, such as: propellant and propulsion systems for desaturation of the rate gyros, reboost, phasing burns and debris avoidance maneuvers; redundant life support for U.S. systems; sustaining engineering for the Russian-built, U.S.-owned Functional Cargo Block (FGB); goods and services related to Russian Segment systems training for on-orbit ISS operations; supplies and sustaining engineering on the Russian-built toilet in the non-Russian segment; and potential de-orbit assistance. Roscosmos will continue to need NASA capabilities including: electrical power for Russian core systems and payloads; redundant life support for Russian systems; attitude control; communications downlink telemetry and commanding to augment limited Russian ground site coverage; and training for non-Russian Segment operations.

If the Russians decided to withdraw from the ISS after 2020, NASA would require lead-time and resources to develop those capabilities for which we are currently reliant on Roscosmos.

QUESTION 15:

NASA has committed to a commercial model for future cargo and crew transportation to low Earth orbit. The business viability of this model is a long-standing topic of debate.

QUESTION 15a:

The FY 2015 budget proposes to eliminate a previously planned Commercial/ Cargo flight to the ISS. How would that affect the viability of the current Commercial Cargo providers?

ANSWER 15a:

NASA has consulted with its CRS providers; even with the deletion of this flight in the FY 2015 budget, the providers will still be viable.

QUESTION 15b:

NASA officials have stated that a smaller number of cargo flights to the ISS, each with a larger capacity, might be preferable for operational reasons. What would be the impact of that change on the viability of the current commercial cargo providers?

ANSWER 15b:

NASA's CRS-2 requirements will be detailed in a future Request for Proposals (RFP) (see response to Question #18). It will be up to proposing entities to determine their business case based on any mass-per-flight parameters that may be stipulated.

QUESTION 15c:

The Space Shuttles flew 135 missions over a period of more than 30 years. If ISS operations continue to 2024 as now proposed, that extension would allow about 12 years of Commercial Cargo operations and up to 7 years of commercial crew operations. If the purpose of the Commercial Crew and Cargo programs is to develop a market (rather than just a capability), what customers will that market serve after ISS?

ANSWER 15c:

NASA is working to encourage the growth of a low Earth orbit (LEO) space economy that will continue to develop even after the end of International Space

Station's (ISS) lifetime. Private enterprise and affordable commercial operations in LEO will enable a truly sustainable step in our expansion into space — a robust, vibrant, commercial enterprise with many providers and a wide range of private and public users will enable U.S. industry to support NASA and other Government and commercial users safely, reliably, and at a lower cost.

QUESTION 16:

Recent events in Ukraine have made U.S. relations with Russia more challenging.

a. Please describe any consequences of these developments for NASA's relationships with the Russian Space Agency and the Russian space industry. What measures is NASA taking to protect U.S. interests?

b. Has there been any change in U.S.-Russian cooperation regarding the ISS? Russian *Soyuz* spacecraft are currently the only option for U.S. astronaut access to the ISS. Has there been any change in plans for *Soyuz* flights carrying U.S. crews? Has there been any change in plans for Russian *Progress* cargo flights to the ISS?

c. Some U.S. rockets use Russian engines, such as the NK-33 engine used in the Antares and the RD-180 engine used in the Atlas V. Given recent lawsuits and court rulings that have called into question the availability of the RD-180, what plans do you have in place to cope with the possible loss of the Atlas V or Antares as a launch vehicle?

ANSWER 16a-c:

Space cooperation has been a hallmark of U.S.-Russia relations, including during the height of the Cold War, and most notably, in the past 13 consecutive years of continuous human presence on board the International Space Station. Ongoing operations on the ISS continue on a normal basis with the safe return of an American astronaut on May 13th and the launch of a new crew on May 28th, all on the Russian Soyuz spacecraft. Progress flights to the ISS also continue as planned.

The success of the ISS program is based on the mutual dependence of all partners and clearly recognizes the unique contributions they each provide to the program. As such, it is in the interest of all ISS partners to continue our normal operational and programmatic cooperation and not to allow disruption of any of the activities that have maintained continuous human presence on orbit for over a decade. We have not received any official notification from the Government of Russia on any changes in our space cooperation at this point.

If the current situation deteriorates such that there are indications that the ISS partnership might be affected, contingency planning by NASA related to the space station must maintain the safety of all crewmembers including Russian, American and other international partner astronauts.

In the event of a restriction on the NK-33 and/or RD-180, NASA would look to its commercial launch providers to develop a solution which would enable them to deliver their contracted services.

QUESTION 17:

As a result of a requirement that NASA devote at least $100M to a satellite servicing development program, a Commercial Cargo flight has been cancelled. What was on that flight and how does NASA intend to make up the lost research or supplies that will not be available as a result?

ANSWER 17:

The FY 2015 Commercial Resupply Services (CRS) flight that was deleted had not yet been manifested. Therefore, a specific list of cargo/science that will be deleted or deferred is not available. However, on average a CRS flight takes up approximately 1.5 metric tons of cargo. The cargo on CRS flights include crew supplies and consumables (food, oxygen, filters, etc.), equipment (on-orbit spares, tools, etc.), and science. The International Space Station (ISS) Program is working to minimize any impacts from the flight deletion, but it will ultimately result in less overall cargo transportation available for research. The specific impacts will depend on a variety of factors including whether planned spares can be delayed due to positive performance and if research transportation is requested at the capacity and timing estimated by the Program.

QUESTION 18:

NASA recently released an RFI for the next Commercial Resupply Contract for the International Space Station. Do you expect bids on this contract from companies other than the incumbents? What has changed in this contract from the original contract? Do you believe NASA has gotten the best value it could in the current contract or do you believe there are more savings yet to be achieved?

ANSWER 18:

The Commercial Resupply Services-2 acquisition strategy will be informed by information received in response to the Request for Information (RFI), released earlier this year. Details are pending, but NASA anticipates releasing a Request for Proposals (RFP) later this year. The primary purpose of the RFI was to inform industry of NASA's resupply service requirements and to collect information on key parameters that would help NASA refine and mature the follow on acquisition plan for procuring safe, cost effective, timely, and reliable ISS research and cargo resupply, disposal, and return services. Multiple companies expressed interest in bidding on the CRS-2 procurement. A list is posted on the website.

The RFI synopsis may be accessed at the NASA Acquisition Internet Service (NAIS) site:
https://prod.nais.nasa.gov/cgibin/eps/synopsis.cgi?acqid=159700

Please see attached RFI for further details at:
http://procurement.jsc.nasa.gov/crs2/RFI-CRS2-022014-v2.docx

NASA is pleased with the value received under the current CRS contracts. Future pricing on CRS-2 will be subject to negotiations.

QUESTION 19:

The Commercial Cargo providers are no longer under development and have begun operational flights to the International Space Station. NASA signed two CRS contracts. The SpaceX contract is valued at $1.6B for 12 missions and Orbital contract is valued at $1.9B for eight missions.

QUESTION 19a:

Are both of the partners on track to fulfill their mass requirements on the contract?

ANSWER 19a:

The ISS Program is receiving the anticipated value for the mass delivered to the ISS under the Commercial Resupply Services contracts. In addition, the ISS benefits greatly from both the return and disposal capabilities provided by the vendors.

QUESTION 19b:

What enforcement mechanisms are available to NASA if one of the partners defaults on the contract requirements?

ANSWER 19b:

NASA will only pay its CRS contractors when they meet milestones. In the event of a delay beyond 30 days, NASA would negotiate with the contractor, and this could result in an equitable adjustment. In the event of a failed mission, the contractor is not required to re-perform the mission. The CRS contracts contain clauses regarding recovery of interim milestone payments and require the contractor to forfeit the final milestone payment in the event of a failed mission.

QUESTION 19c:

When one of the providers does not meet a set launch date, how is NASA compensated for the delay?

ANSWER 19c:

Details on launch dates are set out in the CRS contract. Specifically in the case of a launch delay, section 20.3 states:

In the event of a NASA- or Contractor-requested delay of the delivery window beyond 30 days, the Contracting Officer shall direct the Contractor, in writing, of

the revised delivery window, and allow the Contractor to submit a proposal for the effect of any delay beyond 30 days on the task order price of all affected Contract Line Item Numbers (CLINs), delivery schedule, or other terms of the contract. This may result in any of the following: an equitable adjustment to the price of all affected CLINs in the task order (if any), change in the delivery schedule, and change in the period of performance.

QUESTION 19d:

What are some examples of NASA using its enforcement mechanisms to ensure the best value for the taxpayer?

ANSWER 19d:

NASA has received equitable adjustments as a result of mission delays. These have taken the form of additional testing and analytical products provided by the contractor at their expense.

QUESTION 19e:

If requirements are not met, and in-kind contributions are exhausted, will NASA seek monetary compensation?

ANSWER 19e:

The termination clause in the CRS contracts is a standard FAR Part 12 termination provision. It includes government termination for convenience or termination for cause, such as failure to comply with the contract's terms and conditions.

The payments under CRS are made when milestones are achieved, and are interim payments until the final milestone event. In the event of termination for cause, NASA may recover previous milestone payments. In the event of a launch failure, the provider would not get the launch and the cargo delivery payments; this could represent up to 30 percent of the total mission payment.

QUESTION 20:

In 2009, the Augustine committee concluded that without substantial increases in NASA funding, human exploration could not continue "in any meaningful way."[9] Since that time, NASA's annual funding has fallen by more than $1B, and the FY 2015 budget proposes a further reduction. Do you consider NASA's current human exploration activities "meaningful"? If so, how do you reconcile that with the conclusions of the Augustine report?

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[9] Review of U.S. Human Spaceflight Plans Committee. *Seeking a Human Spaceflight Program Worthy of a Great Nation*, October 2009.
http://www.nasa.gov/pdf/396093main_HSF_Cmte_FinalReport.pdf.

ANSWER 20:

Consistent with the NASA Authorization Act of 2010, NASA's space exploration architecture is based on new launch and crew systems to conduct cis-lunar missions. These initial missions, along with the development of new technologies and in-space capabilities, will form the foundation for missions to other destinations, and provide operational experience prior to the further human expansion into space. These systems, along with commercial crew transportation, will support multiple missions and destinations, enable private access to – and use of – space and complement and advance other NASA, national and international objectives and goals. This architecture is intended to be sustainable over the long term and affordable. This endeavor is responsive to changing environments, including on-ramps for new technologies, new approaches, and other space players. We also are tightly coupling the planning of our science and technology portfolios with this strategy.

Our architecture is designed for long-term human exploration of our solar system, including the goal of human missions to Mars. NASA's near-term strategy for exploration has four prongs: using the unique environment of International Space Station (ISS) to conduct the research and technology demonstrations necessary to keep our crews safe and productive on long-duration spaceflights; partnering with commercial entities to develop the capacity to transport cargo and crew affordably to low-Earth orbit (LEO); working in cooperation with other NASA Directorates to better understand exploration destinations and improve our ability to work there; and moving outward to deep space with Orion and the Space Launch System (SLS) to take us there. Orion and the SLS are foundational capabilities for the implementation of our integrated human and robotic exploration strategy. We will then travel beyond LEO to the proving ground of cis-lunar space, where we will expand and test our capabilities in a rendezvous with a redirected asteroid in lunar orbit. These steps will build the foundation for further deep-space exploration. NASA's architecture is responsive to NASA Human Exploration and Operations' strategic principles for exploration implementation. The principle primarily applicable this question is: Implementable in the ***near-term with the buying power of current budgets*** and in the longer term with budgets commensurate with economic growth.

With the select technologies and techniques we develop, we will enable expeditions to multiple destinations, ultimately allowing us to pioneer Mars and other destinations as we lay the groundwork for permanent human settlements in the solar system. This approach is consistent with the "Flexible Path" strategy favored by the Augustine Commission.

QUESTION 21:

NASA's Earth Science budget has ballooned 63 percent since 2007, while NASA's core mission of space exploration (both human and robotic) has been consistently cut. When 13 other federal agencies fund climate research and only one-agency funds space exploration, why is NASA constantly burdened with funding other agency's requirements and insufficient funding requests from this

Administration?

ANSWER 21:

The Space Act that created NASA states that the first objective for NASA is to contribute to "The expansion of human knowledge of the Earth and of phenomena in the atmosphere and space." Thus Earth Science has always been part of NASA's "core mission."

The Earth Science budget declined by approximately $1B from FY 1996 to FY 2006. The increase since 2007 is more accurately characterized as a return to historical funding levels. While NASA collaborates closely with the other Federal agencies involved in climate research, NASA remains the only one that enables Earth observation in support of research from the unique vantage point of space through the procurement, development and launching of Earth monitoring spacecraft.

The Global Change Research Act of 1990 specifies NASA as one of several agencies to conduct and sponsor global change research, including climate related research. As the nation's primary civil space agency, NASA focuses on providing space-based, global observations to enable research and scientific understanding about the Earth system and its processes. The National Plan for Civil Earth Observations calls for sustained observations and experimental observations, and NASA focuses on space-based platforms to advance research, technology development, and national capabilities consistent with its mandate.

QUESTION 22:

Since 1972, the Landsat program has provided standardized scientific data valued as an essential resource. Have user requirements and technological capabilities fundamentally changed since the launch of Landsat 8 last year? What will happen if a commercial supplier of future LandSat data encounters financial difficulties?

ANSWER 22:

NASA and its Landsat partner, the U.S. Geological Survey (USGS), are studying a programmatically sustainable land imaging system that balances measurement capability, likelihood of data continuity (minimizing risks of gaps to the extent possible), and cost/affordability. Through FY 2014, NASA is carefully evaluating options for a sustained, space-based, global land imaging capability for the nation. Near-term activities led by NASA, in cooperation with USGS, are focusing on defining the scope, measurement approaches, cost, and risks of a viable long-term land imaging system that will achieve national objectives. Ongoing evaluation and design activities include consideration of stand-alone new instruments and satellites, as well as potential international partnerships. More information about the sustained land imaging study is available at: http://espd.gsfc.nasa.gov/landimagingstudy/index.html

We are working to define a robust, sustainable land imaging architecture that is not

susceptible to a single point failure by any element or component. Consequently we do not anticipate that any architecture meeting the reliability objectives would feature a single commercial supplier as the sole provider of land imaging data.

QUESTION 23:

Despite repeated Congressional objections to cuts to Planetary Science, the FY 2015 budget request cuts $65M for funding of Planetary Science missions. How will the proposed cuts affect specific missions?

ANSWER 23:

The FY 2015 President's Budget Request shows a total budget for Planetary Science of $1,280.3M for FY 2015. This request is part of a broader approach to maintain balance across NASA within a constrained fiscal environment, and to ensure that the President's FY 2015 budget request is consistent with available resources while still maintaining the highest priority science across the portfolio of Planetary Science programs.

This budget fully funds development of InSight (Interior Exploration Using Seismic Investigations, Geodesy and Heat Transport), OSIRIS-REx (Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer), and the Mars Rover 2020; initiates a new Discovery mission; supports the production of planetary exploration enabling Plutonium-238 in partnership with the Department of Energy; provides for instrument contributions to ESA's BepiColombo, ExoMars and JUICE (JUpiter ICy moons Explorer) missions; and continues development of a potential mission to Europa. Additionally, the FY 2015 request maintains support for planetary science technology and research awards.

This funding level also continues funding for missions currently operating, though with reduced budgets for missions in extended operations. As part of the FY 2015 request, two extended missions are being considered for termination; however, the specifics will be validated during the Senior Review and additional funding is proposed as part of the President's Opportunity, Growth and Security Initiative.

QUESTION 24:

How will decreases in the Planetary Science budget affect U.S. leadership 'in planetary science? How will this affect the retention of space scientists and engineers?

ANSWER 24:

NASA continues to be the world leader in compelling space science missions and discoveries, and the FY 2015 budget request is supportive of these endeavors. Upcoming Planetary Science missions such as InSight, OSIRIS-REx and Mars 2020 provide opportunities for supporting scientists and engineers to retain and develop their skills. In addition, the FY 2015 request maintains stable funding for planetary science technology and research awards. Overall, NASA does not

anticipate that the FY 2015 budget request for planetary science would have a negative impact on the retention of U.S. scientists and engineers.

QUESTION 25:

In the most recent report of the Astronomy and Astrophysics Advisory Committee, it is noted that while the FY 2015 budget shows an increase of 1.2 percent in basic R&D funding across government agencies, overall funding for astronomy and astrophysics is down 2.7 percent. How will the proposed cuts affect Astronomy and Astrophysics missions and U.S. leadership in the field?

ANSWER 25:

The President's FY 2015 funding request for NASA Astrophysics is 9.1 percent lower than the FY 2014 appropriated level. The primary impact of this reduction is that the Administration proposes that the Stratospheric Observatory for Infrared Astronomy (SOFIA) be put into storage. With the proposed reduction, the U.S. will not operate SOFIA; there is no projected impact on any other missions.

QUESTION 26:

We are encouraged to see that the budget requests funding to study WFIRST mission designs. However, there is no money budgeted for future years. What are the plans for moving forward with the design process beyond FY 2015?

ANSWER 26:

NASA has budgeted for continued formulation studies for WFIRST beyond FY 2015. The NASA Congressional Justification document shows, on page 36, that the WFIRST budget line (also known as Astrophysics Decadal Strategic Mission) has a notional run-out budget for future years. The notional budget for future years is:

FY 15 - $14.0M
FY 16 - $14.0M
FY 17 - $21.1M
FY 18 - $51.4M
FY 19 - $198.0M

QUESTION 27:

The National Academies recently released a report evaluating the implementation of WFIRST/AFTA versus the original WFIRST proposed mission in the New Worlds New Horizons decadal survey. They expressed concern that adoption of the National Reconnaissance Office (NRO) telescope for use with WFIRST would cause more risk and greater expense than the original design, in part, because of the expense of modifying the gifted telescope. Is it worth modifying the NRO assets if it will cost more than developing the original WFIRST mission concept?

ANSWER 27:

NASA will use the NRO assets "as is" to the maximum extent practicable. By using the NRO assets, NASA intends to reduce costs and decrease risks for WFIRST while increasing the science yield. As recommended by the NRC Study, NASA will do qualification testing of the NRO assets for WFIRST during FY 2014 to further reduce the risks of using the NRO assets.

QUESTION 28:

This is a critical year for the James Webb Space Telescope. It will undergo rigorous testing to determine that the instruments and components will integrate properly and function correctly.

QUESTION 28a:

What indicators would you expect to see in the next year to demonstrate that everything is progressing as it should toward a 2018 launch date?

ANSWER 28a:

For JWST to continue its successful progress towards the 2018 launch readiness date, we expect to complete all the planned necessary changes to the science instruments (November 2014-February 2015) building on the recent successful cryo-vacuum test, complete the commissioning of the Chamber A and its test equipment at the Johnson Space Center's (December 2014), continue the planned progress of manufacturing the spacecraft bus and sunshield (FY 2015), and improve the schedule performance of the cryo-cooler compressor assembly (by late Spring 2015). To be successful, all these activities will need to occur within the planned budget and reserves and not consume excessive schedule margin.

QUESTION 28b:

What indicators would you expect to see if things weren't progressing properly?

ANSWER 28b:

Troublesome indicators for JWST would include low programmatic performance indicators that would suggest unallocated future expense funds are not adequate to maintain critical tasks in the planned physical year, a major failure of a science instrument during cryo-vacuum testing, or deferral of significant work into the future (one of the problems that necessitated the replan in 2011). All these indicators are tracked at least monthly (for financial and schedule performance) or weekly (project risks). Our science instruments just completed a successful Pre-environmental review for CV testing giving us confidence that the instruments are ready to go and our plans for testing them are sound.

QUESTION 29:

It was encouraging to see the budget request for $15M for the design of a Europa mission. Considering there isn't money budgeted for mission development in coming years, what will be done with the mission design following FY 2015?

ANSWER 29:

As part of our efforts to implement the objectives of the latest Planetary Science Decadal Survey, NASA continues to evaluate options for a mission to explore the habitability of Europa. In the interim, work on the flyby mission concept continues to be developed and reviewed, with an independent Mission Concept Review completed in September 2014.

QUESTION 30:

In FY 2013 and FY 2014, Congress funded the development of a Europa mission at $75 and $80M, respectively, for a total of $155M.

a. How has that money been invested in a Europa mission?
b. Has any mission proposal resulted from that investment?
c. If so, please provide the Committee with the results.
d. How do previous investments in Europa mission formulation relate to this year's budget request?

ANSWER 30:

Europa exploration has consistently been rated as among the highest priority scientific pursuits for NASA and as such, the money invested has been utilized for a logical sequence of activities in the development of a potential mission. NASA has worked diligently to ensure that all prior and current investments directly enhance a potential Europa exploration mission, and that each year's efforts build on past work.

NASA continues to follow the direction in the FY 2013 and FY 2014 appropriations acts and, as such, funding has been used to study a variety of Europa mission options including lander, orbiter and flyby concepts. The mission concept utilizing a flyby has matured significantly during FY 2013 and FY 2014, including development of requirements, configuration options, payload priorities, power options, and risk reduction tasks. The mission concept team continues to develop and analyze the associated trade space for both commercial and SLS launch vehicle options. An independent Mission Concept Review occurred in September 2014. This was the first formal milestone under the standard NASA processes for a potential new mission. NASA evaluated responses to a Request For Information (RFI) for Europa mission concepts costing less than $1B (in FY 2015 dollars), excluding the costs of launch services.

In addition, FY 2013 investments were made in instrument technology to help reduce specific risks associated with the Europa environment. Furthermore, NASA

intends to invest FY 2014 funds by releasing a Program Element Appendix (PEA) of the Stand Alone Missions of Opportunity Notice (SALMON) later this year for Europa instrument science investigations. The PEA will include the detailed science objectives from the decadal survey plus reconnaissance objectives needed to support potential future landing missions. The intent is to broadly address the decadal science objectives, which would allow Phase A studies on up to 15 instruments that cover these objectives. It is expected that these selections would provide the basis for down selecting to the key instruments on a potential future Europa mission. Since the PEA is based upon the decadal science objectives, as will be a future Europa mission, these instruments should be applicable to any future Europa mission option.

QUESTION 31:

Could you explain why, with regards to the Stratospheric Observatory for Infrared Astronomy (SOFIA), NASA did not follow its usual process of conducting a senior Review," which engages experts in the community to set priorities and make tough decisions on whether to end a mission?

ANSWER 31:

The decision to place SOFIA into storage, in the event that no partners stepped up to provide additional funds, was made primarily for budgetary reasons and due to SOFIA's high annual operating costs. With the successful commissioning of its fourth science instrument in February 2014, SOFIA entered its operations phase in May 2014. Senior Reviews are reviews of the science productivity of operating missions to support an assessment, based on demonstrated science accomplishments, and the anticipated science value of an extended mission.

QUESTION 32:

How did the German space agency, DLR, receive this announcement by the U.S. on SOFIA?

ANSWER 32:

Our German partners at DLR were first notified on February 28, 2014 of NASA's plans regarding SOFIA via a phone call from Administrator Bolden to DLR Chairman Woerner.

QUESTION 33:

How do you justify the decision to spend $1.1B in NASA funding over the past decade to build SOFIA and then cut funding for the project just eleven days after it was declared fully operational? What precedent in NASA exists for this sort of decision?

ANSWER 33:

While significant funding has been spent to develop SOFIA, this funding is less than half of the estimated $3 billion life-cycle cost of the program. NASA is very aware that its budget decisions have consequences to our science investments. NASA has to make tough budget decisions in order to maximize the scientific return of the public investments in the astronomical sciences. The decision to propose, as part of the FY 2015 NASA budget request, to put SOFIA into storage was primarily a budgetary decision driven by the tight budget caps in the Bipartisan Budget Act of 2013. SOFIA's scientific priority relative to other projects within NASA's Astrophysics portfolio was a secondary consideration. While it was the third-highest priority in the 1990 Decadal Survey as a medium-class mission, its operations costs are the second largest of all NASA science missions, with only Hubble costing more.

QUESTION 34:

Congress and the Administration wisely depend on external advice when it comes to prioritizing science missions. A March 17 American Astronomical Society statement on Community-based Priority Setting in the Astronomical Sciences expresses the importance of following guidance from the scientific community. It states "Efforts that go outside these longstanding advisory processes in an attempt to benefit or harm specific projects or alter priorities are counterproductive and damage the scientific endeavor as a whole." While this statement doesn't mention SOFIA specifically, it is clearly in response to the Administration's decision to terminate the program without a formal review. Why didn't the Administration seek outside input on this decision?

ANSWER 34:

The 1990 Decadal Survey performed by the astrophysics community ranked SOFIA as the community's third most important medium-sized project for the proceeding ten years. The decision to propose, as part of the FY 2015 NASA budget request, to put SOFIA into storage was primarily a budgetary decision driven by the tight budget caps in the Bipartisan Budget Act of 2013. SOFIA's scientific priority relative to other projects within NASA's Astrophysics portfolio was a secondary consideration to accommodating the level of NASA's FY 2015 Astrophysics budget request ($607M) compared with the FY 2014 appropriated level ($668M). Among the possible Astrophysics projects considered for reduction, SOFIA was identified for two reasons. First, it is the only Astrophysics project that was not a first priority of a Decadal Survey. Second, while it was a priority in the 1990 Decadal Survey as a medium-class mission, its operations costs are the second largest of all NASA science missions, with only Hubble costing more.

QUESTION 35:

How much is "mothballing" SOFIA expected to cost?

ANSWER 35:

The cost of "mothballing" SOFIA would vary significantly depending on what condition the aircraft is left in. Abandonment would be inexpensive, but would make it difficult to reuse the plane. On the other end of the spectrum, the joint NASA-DLR SOFIA Working Group has conducted a preliminary study of the effort required to mothball the SOFIA program and to appropriately dispose of the assets – primarily spare parts and documentation. Based on the cost and duration of previous large aircraft retirement, mothballing the SOFIA program could cost as much as $50M. Approximately 200,000 labor hours are required to execute an orderly disposition of the aircraft, in addition to significant costs to mothball other mission systems and associated facilities.

QUESTION 36:

How much time do NASA and DLR have to find other partners for SOFIA before SOFIA is to be shut down?

ANSWER 36:

A final decision on SOFIA's future operations is dependent on the outcome of the FY 2015 Appropriations process.

QUESTION 37:

SOFIA is scheduled to go to Germany this spring for a routine heavy maintenance service of the aircraft. Germany is paying the cost and has a contract in place, 'can you confirm that this heavy maintenance the Germans are planning will occur as scheduled?

ANSWER 37:

Under the NASA/DLR agreement, NASA is responsible for maintenance of the aircraft, and DLR is responsible for the maintenance of the telescope. NASA and DLR have arranged for a common provider (Lufthansa Technik) to provide heavy maintenance of both systems at the same time in summer 2014. DLR holds both contracts and will be paying for both heavy maintenance visits using German funding; NASA does not have a contractual relationship with Lufthansa Technik and has no mechanism to provide US funding. NASA has agreed to reimburse DLR for the cost of the aircraft heavy maintenance visit through fuel credits for German SOFIA flights in FY 2015-2018. We can confirm that the German Aerospace Center (DLR) and NASA have decided to proceed with the scheduled Heavy Maintenance Visit for SOFIA in Germany as planned; SOFIA arrived in Germany at the end of June, 2014, and the Heavy Maintenance Visit is underway.

QUESTION 38:

If SOFIA were "mothballed," would NASA be able to assemble scientists and engineers to return to the project?

ANSWER 38:

NASA recognizes the challenge of reassembling the SOFIA team in a "restart" should the project be put into storage.

QUESTION 39:

Are there concerns at NASA that withdrawing our support from an international partnership could cause problems with future international cooperation on space missions, similar to those experienced after the ExoMars experience?

ANSWER 39:

Even the most robust space partnerships, such as those among the International Space Station partners, have weathered such developments. Our partners are very aware that in all instances our cooperation is based on the availability of appropriated funds, just as we are aware that their participation has similar funding constraints. NASA has a long history of very successful cooperation with nations around the world, and a part of that history has from time to time included some decisions by NASA and some by our international partners to re-phase, redesign, or even terminate planned cooperative activities. Some examples of the rich and robust NASA-DLR cooperation at the forefront of discovery include the Gravity Recovery and Climate Experiment (GRACE), the Fermi Gamma-ray Space Telescope, the Dawn mission now on its way to the asteroid Ceres, and the Mars Science Laboratory/Curiosity. Our long history of mutually beneficial collaboration will continue well in the future, bilaterally through missions like InSight, and multilaterally through ESA where our work in development expands to such projects such as James Webb Space Telescope (JWST) and ExoMars/MOMA.

Other countries continue to work with NASA on a wide variety of international partnerships, and we have not noticed any change in their willingness to work with us. Currently, NASA has over 600 active agreements with over 120 countries and anticipates that international cooperation will remain a cornerstone of all of its future activities.

QUESTION 40:

There is always a competition for resources between extending the lifetime of currently operating missions and developing the next generation of new missions. Extended operations increase the research return on past investments. New missions provide new capabilities and sustain the flow of future research opportunities.

QUESTION 40a:

In general, what is your philosophy for how to balance these two competing demands?

ANSWER 40a:

NASA's philosophy is to use the Senior Review process to assess the value of extending operating missions. Senior Reviews are evaluations of the science productivity of operating missions to support an assessment, based on demonstrated science accomplishments, and the anticipated science value of an extended mission. By using the Senior Review process, NASA balances the competing demands of extending operating missions and developing new missions.

QUESTION 40b:

How does the current era of flat or decreasing budgets affect the balancing process?

ANSWER 40b:

The current era of flat or decreasing budgets for NASA makes the balancing process very difficult. Without the additional funding provided through budget growth, funding for development of new missions is freed up through the launch of missions, the termination of mission operations, or other reductions of base activities.

QUESTION 40c:

The FY 2015 budget proposes to put SOFIA into storage, just months after it achieves its full operating capability. This decision was made without the usual senior review. To what extent does this set a precedent for how NASA will handle these issues in the future?

ANSWER 40c:

The decision to place SOFIA into storage was made primarily for budgetary reasons. SOFIA operations costs are the second largest of all NASA science missions, with only Hubble costing more.

With the successful commissioning of its fourth science instrument in February 2014, SOFIA entered its operations phase in May 2014. Senior Reviews are reviews of the science productivity of operating missions to support an assessment, based on demonstrated science accomplishments, and the anticipated science value of an extended mission. Future budget reductions, if any, will be handled on a case-by-case basis.

QUESTION 41:

The Aeronautics Research Mission Directorate (ARMD) announced a new strategic vision for its research. Despite this, the only specific change in ARMD program content in the FY 2015 budget is a reduction in funding for research on rotorcraft.

a. Which specific aeronautics research topics will receive greater emphasis and

funding under the new strategy? Which specific topics will receive less emphasis and funding?

b. If these shifts are not evident in the FY 2015 budget, when can Congress expect to see them fully implemented?

ANSWER 41:

The restructuring of the aeronautics research programs as described in the FY 2015 Congressional Budget Justification will happen upon receipt of the FY 2015 appropriation. The transition of specific research activities in order to align the portfolio with the aeronautics strategy implementation will start at that time.

Eventually, we will phase out research not directly related to the six strategic areas (also being referred to as "thrusts") (Safe, Efficient Growth in Global Operations; Innovation in Commercial Supersonic Aircraft; Ultra-Efficient Commercial Vehicles; Transition to Low-Carbon Propulsion; Real-Time System-Wide Safety Assurance; and Assured Autonomy for Aviation Transformation). We will conclude the non-"thrust" related work over the next several years. As that work is phased out, funding will be redirected to new and emerging technical areas. Those new and emerging technical areas will be identified via a ten-year portfolio planning exercise, feasibility assessment capability, and the Convergent Aeronautics Solutions Project, in which NASA will prove the feasibility of solutions to "big questions" that need answers to sustain and grow aviation in the U.S. The biggest change we anticipate implementing in FY 2015 is phasing out of, and ending, much of the vehicle-related work in the current Aviation Safety Program. This work is presently being performed in the Vehicle Systems Safety Technologies Project. We believe that NASA can best contribute to the safety of the future aviation system by developing pioneering methods for real-time, system-wide safety monitoring and assurance. The funding from areas of our safety portfolio that we are de-emphasizing is used to fund the new Convergent Aeronautics Solutions project and to increase the external seedling research. FY 2015 will also see the end of the Environmentally Responsible Aviation (ERA) Project within the Integrated Systems Research Program. NASA will transition technical knowledge gained through the ERA Project 6-year effort to stakeholders, and will continue to work on technologies to reduce the environmental impacts of aviation. While funding for rotary wing research is reduced in FY15, with a tightly focused portfolio in rotary wing research NASA will continue to pursue those innovative ideas and technical challenges that will enable relevant new vertical lift capabilities. In addition, we have worked hard to prioritize the portfolio to have the most impact on industry and also complementing the work of other government partners in the FAA and DoD. Other changes in research content will occur in the outyears to address all six strategic R&D thrust areas in a more balanced manner and to involve more flight research and air traffic management technology demonstrations.

QUESTION 42:

The Aeronautics Test Program was established to ensure that NASA gives sufficient attention and resources to its test facility infrastructure. Under the new strategy, how will

NASA ensure that wind tunnels and other test facilities continue to be adequately maintained and resourced for their users within NASA and at other federal agencies?

ANSWER 42:

Although the Aeronautics Test Program (ATP) will no longer be a separate program, the two projects within ATP will transition intact into new programs. ATP currently consists of the Ground Test Project and the Flight Test Project, and these projects will become part of new projects within the Advanced Air Vehicles Program and the Integrated Aviation Systems Program, respectively. Within the new program structure, the Advanced Air Vehicle Program will include a project dedicated to the stewardship of NASA aeronautics ground testing capabilities. That project will have the dual charter to sustain, maintain and upgrade testing capabilities as necessary, while also developing longer-term plans for the strategic capabilities that will be required to address the Technical Challenges identified for the six strategic R&D thrust areas. These changes are being implemented to enable more agile research practices that make appropriate use of analytical and experimental tools, i.e., employing a more robust combination of numerical simulation, ground testing and experimentation, and flight research throughout all research phases.

It is critically important to ARMD to ensure the future viability of ground and flight assets. In the longer term, the suite of technical capabilities will evolve to become more integrated within ARMD research programs and to be managed more effectively at Centers so that strategic assessments of and investments into key ground and flight testing capabilities will enable innovative, multi-disciplinary research practices along with appropriate use of numerical simulation capabilities.

QUESTION 43:

NASA has previously proposed to reduce or eliminate rotorcraft research on several occasions. Why is there so much instability in NASA's efforts to fund rotorcraft research? How has the reduction in rotorcraft research been coordinated with other agencies?

ANSWER 43:

Funding for the Revolutionary Vertical Lift Technology (RVLT) Project will be $15M per year, which is about a 30 percent reduction from the current Rotary Wing Project. This funding shift reflects a portfolio focused on research and technologies that benefit the civil rotorcraft industry versus those for solely military or dual applications. FY 2014 and FY 2015 will be transition years to complete and transfer as much of the current technical results/outcomes as possible to the DoD and U.S. industry. Some elements of the current portfolio will be terminated before planned completion because of priority decisions made in response to the reduced budget. The Tilt-rotor Test Rig (TTR) is an example of work that will need to be transitioned to the DOD ahead of the current plan in order for the capability to be fully realized. The inter-agency coordination associated with these changes has occurred through multiple channels including the NASA involvement in the Future

Vertical Lift Steering Committee. The new RVLT Project will shift its focus to new Technical Challenges (e.g. the low noise certifiable rotor). The plan is to use FY 2015 to investigate potential technical challenges and approaches and then decide on support in FY 2016 and beyond.

In addition to focused vertical lift research in the RVLT Project, another opportunity is to lay the groundwork for future research in N+3 vertical lift capabilities as part of the Transformative Aeronautics Concepts Program. A strong effort in this area will set the stage for potential, new Technical Challenges to be identified for the next RVLT portfolio and will likely incorporate a much greater autonomy component as well as novel propulsion approaches.

QUESTION 44:

In September, NASA selected six companies to participate in government and industry partnerships to advance composite materials research and certification. What progress has been made in composite materials research since the announcement of this partnership, and how is research being coordinated between these six companies and NASA to ensure efficiencies and to prevent duplicated efforts?

ANSWER 44:

The six companies currently in the Advanced Composites Consortium (ACC) are organized as a public private partnership to collaborate with NASA and the FAA in composites research. The ACC will address and fund the research and technology development needs of NASA and industry to reduce significantly the time for development, verification, and regulatory acceptance of new composite materials and structures. NASA and the selected industry partners have recently completed negotiation of the Collaborative Agreement to govern the operation of the ACC, defining the operational structure, cost sharing, and intellectual property and data rights for multiple-member industry and government collaborative research teams. The ACC is approaching operational status. While agreements were negotiated, each entity continued independent research efforts, but also participated as a team member in three technical interchange meetings organized by NASA to identify common technical challenges, create technology development roadmaps, and coordinate team plans in preparation for collaborative research to be conducted by the ACC.

QUESTION 45:

In December, the FAA announced the selection of six test site operators around the United States to develop unmanned aerials systems research across the country. How will NASA coordinated its UAS research efforts with these test sites? What specific research goals does NASA have for FY 2015 in cooperation with these test site operators? Does NASA intend to provide funding to these test sites or conduct research at the sites?

ANSWER 45:

NASA has built close partnerships with the Federal Aviation Administration's UAS Integration Office, the Radio Technical Commission for Aeronautics Special Committee 228 (i.e. UAS Integration) working groups, the UAS Aviation Rulemaking Committee, the Joint Planning and Development Office and the Department of Defense.

To validate anticipated operational standards, NASA is developing a test environment to enable flight-testing of UAS concepts and technologies without incurring the risk of testing in the actual National Airspace System (NAS). This test environment, referred to as a Live Virtual Constructive – Distributed Environment (LVC-DE), is a complex system that can simulate the air traffic control environment, background air traffic and Unmanned Aircraft (UA) as well as accommodating actual test UA in real air traffic. The system has the ability to integrate NASA Centers, FAA facilities and other institutions thus providing the capability to utilize unique flight and simulation assets from geographically dispersed facilities.

The primary purpose of the test sites is to provide test access for industry. NASA currently has access to restricted airspace at Armstrong Flight Research Center (AFRC) and is using that airspace to support research in various ARMD Programs. As soon as the FAA's UAS test sites are operational, NASA will consider them when choosing the most appropriate location to conduct flight research, as well as networking unique capabilities that the test sites may offer into the LVC-DE.

QUESTION 46:

The Administration's FY 2015 request does not include any funding for the Joint Planning and Development Office, the office in the Federal Aviation Administration that previously coordinated the Next Generation air traffic control modernization.

a. How will the re-organization of ARMD change NASA's approach to the Next Generation air traffic control modernization, both in terms of conducting research for new technologies, and in terms of coordinating with other agencies? Do you expect either of these efforts to be impeded by the elimination of the Joint Planning and Development Office?

ANSWER 46a:

Efforts supporting the implementation of NextGen will continue to be supported by NASA within the Airspace Operations and Safety Program. The ARMD reorganization aims to strengthen its contributions to NextGen by combining NASA's Air Traffic Management (ATM) research along with Safety Operations research to deliver integrated solutions for NextGen capabilities that address both the safety and technical challenges of new operations concepts.

NASA does not feel that any research or coordination efforts will be adversely affected by the change of JPDO status. The FY 2014 Consolidated Appropriation Act aligned the responsibilities and personnel of the JPDO within the FAA's Office

of NextGen. The FAA has been coordinating with all partner agencies (including NASA) to incorporate recommendations into a new interagency engagement process, which will ensure coordination across NextGen partners to achieve target goals and objectives. These discussions with the FAA's NextGen Office have been productive thus far. NASA will continue to work with FAA Office of NextGen to ensure coordination and applicability of NextGen research efforts.

Coordination of existing and future NASA NextGen technology related research will continue to be enabled through current collaborative mechanisms such as the NASA-FAA Research Transition Teams (RTT). These teams have demonstrated great success over the last few years transferring NASA NextGen research to the FAA for implementation evaluations, such as the Efficient Descent Advisor and Multi-Sector Planner in 2011, Precision Departure Release Capability and Terminal Scheduling and Spacing along with Controller Managed Spacing in 2013, and the Terminal Sequencing and Spacing tool in July 2014.

QUESTION 47:

The Space Technology Mission Directorate is responsible for the Flight Opportunities program at NASA. It is unclear if the purpose of this program is to develop a market for the suborbital launch industry, or to demonstrate technologies for NASA.

QUESTION 47a:

Can you clarify for the Committee what the purpose of the Flight Opportunities program is?

ANSWER 47a:

The primary purpose of the Flight Opportunities program is to facilitate the maturation of space technologies by providing highly affordable relevant access to space environments. Flying technology payloads on a spectrum on sub-orbital platforms including parabolic flights, balloons, sounding rockets and commercial reusable vehicles, allows for technology demonstration in relevant near space and flight envelop environments at a small fraction of the cost of an equivalent orbital flight. In addition, the program also serves to facilitate the development of a range of alternative approaches for commercial reusable sub-orbital transportation. In some cases these commercial reusable vehicles are developed as a stepping-stone approach to achieving an orbital launch capability, while in other cases vendors are developing such vehicles purely for the sub-orbital market. By purchasing commercial technology demonstration flights from these vendors, Flight Opportunities fosters the development of a more diverse and robust access to space industry.

QUESTION 47b:

Is there a way that experiments could be flown in the Flight Opportunities program to benefit the Science Mission Directorate or is a separate program needed?

ANSWER 47b:

It is noted that the vendors providing flights for the Flight Opportunities program are able to reach altitudes adequate for demonstrating and validating technologies in a relevant flight environments including micro-gravity near space environments. In addition, there are cases where the Flight Opportunities program has facilitated access to flights for peer reviewed science payloads at no cost to the Science Mission Directorate (SMD) or the science research team. Flight Opportunities provides such science flight slots when a technology demonstration flight is not otherwise fully manifested with technology payloads. At this time, STMD has a full technology pipeline and will make flights available to science payloads at cost or on a space available basis in the future. In addition, STMD has worked with SMD to ensure that the Flight Opportunity vendors are included in SMD's sub-orbital solicitations to the science community. In addition, SMD and STMD will be working together in the future on joint solicitations for suborbital science investigations.

QUESTION 47c:

How can NASA leverage the work already done in the current program to benefit multiple mission directorates?

ANSWER 47c:

The Flight Opportunities program has provided the Science Mission Directorate (SMD) with access to all of the program-contracted suborbital flight platforms. The Science Mission Directorate has already included these platforms in many of their ongoing solicitations (e.g., Research Opportunities in Space and Earth Sciences or ROSES, Hands-on Project Experience or HOPE, and Undergraduate Student Instrument Project or USIP). The Human Exploration and Operations Missions Directorate has also included the program platforms under their Human Exploration Research Opportunities (HERO) announcement. The program is on track to fly four SMD/USIP experiments on Masten, Near Space Corporation, and ZeroG Corporation flight platforms. As the emerging suborbital vendors such as Virgin Galactic start flying their vehicles regularly, the program expects the interest from the science community to utilize these commercial platforms to ramp up significantly.

QUESTION 47d:

Are the needs of the scientific community better served using a launch services program model for suborbital flights?

ANSWER 47d:

For the last three years, the NASA Space Technology Mission Directorate, along with SMD and HEOMD, have had sustained access to the contracted platforms under the Flight Opportunities program. The Flight Opportunities program does utilize a suborbital version of the launch services program model already. Like the

Launch Service Program, the program has solicited commercial suborbital flight services from vendors, awarding multiple indefinite delivery indefinite quantity (IDIQ) contracts, and making these IDIQ contracts available to STMD, SMD and HEOMD as explained in the answer to Question 47(b). For example, SMD selected four (out of ten) projects in their Undergraduate Student Instrument Project (USIP) Research Announcement that requested access to STMD-sponsored platforms including parabolic flights, balloons and commercial suborbital flight platforms. The program has set up its next suborbital vendor solicitation that would allow other NASA Mission Directorates and other Government agencies use of these commercial suborbital flight vehicles under contract. Utilizing the launch service program as its model, the Flight Opportunities program allows for annual or more frequent on-ramp of new vendors who have qualified their vehicles.

QUESTION 48:

The Space Technology Mission Directorate has a program called "Exploration Technology Development." This program bares a remarkable resemblance to the Advanced Exploration Systems program in the Human Exploration and Operations Mission Directorate.

QUESTION 48a:

What is NASA doing to ensure there is not a duplication of efforts between these two programs?

ANSWER 48a:

STMD is allocated funding through four Program Resource Accounts (PRA) established in the initial funding allocation described in FY 2012 P.L. 112-55. One of these four PRAs is titled "Exploration Technology Development" and was chartered to "directly support achievement of human exploration goals." Both the Game Changing Development Program and the Technology Development Program activities are funded through the Exploration Technology Development PRA and the Crosscutting Technology Development PRA.

Space Technology generally focuses on developing and demonstrating component and sub-system technologies that will realize dramatic improvements in capability, affordability or reliability of deep-space human exploration missions. Space Technology works with HEOMD (frequently AES but also its other Divisions and Programs ISS, SLS, MPCV, HRP and SCaN) to determine which high-risk high-payoff technology maturations are most in need for future missions. Space Technology develops and demonstrates these technologies and delivers them to HEOMD for incorporation and utilization in their systems.

AES within HEOMD, by contrast, focuses primarily upon advanced systems level integration, whereby HEOMD develops and prototypes complete systems, often including component technologies developed and delivered by programs in Space Technology.

AES and STMD prevent duplication of effort through mutual participation in project formulation, status, and content decision meetings. STMD seeks input from human exploration and AES personnel during STMD program management council meetings where project status and decisions occur. Correspondingly, AES program reviews and selection meetings include STMD to collaborate on upcoming plans.

An example of this synergy is seen with the next generation EVA suit work under development by AES with Space Technology component support. Space Technology has developed and tested specific components of the Portable Life Support System (PLSS) 2.0 and 3.0, including the variable oxygen regulator (VOR) and the Rapid Cycle Amine swing bed (the system that performs CO2 removal). Space Technology has delivered both 2.0 and 3.0 variants of these critical technology components for integration and testing within the full PLSS system. Thus, while AES works on the entire suit system, Space Technology focuses on the individual component technology developments.

Space Technology also delivers advanced technology and capability for HEOMD's programs such as SLS. As an example, consider the STMD development of composite cryogenic propellant tanks. In this case, Space Technology has worked with Boeing since 2012 to solve previously insurmountable challenges in maturing composite materials and manufacturing methods so that they may dramatically reduce the launch vehicle mass and hence substantially increase the up-mass for future launch vehicles. Space Technology formulated this activity such that the end products could see utilization on a future SLS upper stage upgrade. The work was closely coordinated from its inception with the SLS program and SLS management participated in all STMD project reviews. STMD will conduct final ground tests of the 5.5-meter test article this summer and the results of the testing will determine if this technology is ready for infusion into SLS or other launch vehicles. Using composite cryogenic tanks will reduce the mass of NASA's launch vehicles significantly, thus increasing the payload capacity by thirty percent. In addition, the U.S. aerospace industry will gain new materials ready for incorporation into their launch vehicles as well.

Space Technology manages the development and demonstration of technologies that carry crosscutting benefits to its customers: HEOMD, SMD and the Nation's aerospace community. This approach allows NASA to leverage co-investments and partnerships from other customers - SMD, other government agencies, and industry.

The Solar Electric Propulsion (SEP) project illustrates the strength of this multi-customer approach to technology development. The long-term need for human exploration involves deploying a 300kW SEP space tug for deep space missions. STMD is investing in component technologies including large structurally efficient solar arrays, a new class of high-power long-lasting electric propulsion thrusters and power processing units that operate at higher voltages. Each of these component technology investments is inherently designed for extensibility up to the 300kW objective system. STMD is also taking these component capabilities and providing them for use at the 50kW level as a SEP tug for the ARM mission,

which could not be accomplished without SEP. Meanwhile both the commercial space sector and the Science Mission Directorate have shown a keen interest in utilizing the component technologies – especially the deployable solar arrays at the 5kW to 30kW power levels. Commercial satellite firms will soon use these arrays, motivated to their lower weight and improved packaging efficiency, to lower the cost of future communications satellites. SMD sees such value in these new arrays that they will target their use in the next Discovery call. As a result of the careful planning by STMD an architectural pathway now exists the will evolve SEP from the limited capability available today all the way to a human exploration class system. Along the way STMD will provide tremendous benefit to multiple customers including the commercial space industry.

QUESTION 48b:

Why is the Exploration Technologies Development Program not a part of the Advanced Exploration Systems Program?

ANSWER 48b:

Both organizations serve a unique purpose within NASA.

AES validates operational exploration system concepts for future human missions beyond Earth orbit. AES activities are uniquely related to crewed systems and mission operations in deep space, and are strongly coupled to future systems level development. Advanced exploration systems development is focused in four main areas: Crew Mobility Systems, Deep Space Habitation Systems, Vehicle Systems, Operations, and Robotic Precursor Activities. Their emphasis is on integration of new technology and testing of prototype systems in order to reduce risk and improve affordability of exploration mission elements while exploring innovative acquisition approaches and public-private partnerships.

While Space Technology also develops components for NASA's exploration efforts, it also explores external solutions and needs, and seeks collaboration opportunities with industry and other Government Agencies. Space Technology leverages its partnerships with internal and external stakeholders to develop cost-effective approaches to common problems experienced within the aerospace industry. An example can be seen with Solar Electric Propulsion, where NASA is developing the system for a variety of end users. This includes the primary end user (HEOMD for the Asteroid Redirect Mission), but development will also support future science missions and commercial satellites. Ultimately, the system will provide NASA with more capable science missions and the enabling technology needed to deliver necessary materials to Mars for human exploration missions. Space Technology takes on larger technology challenges that require significant focus and industry collaboration to overcome a key technological challenge.

QUESTION 48c:

How does NASA internally govern which technology development programs go

into which program when they are both working on exploration technology development?

ANSWER 48c:

NASA identifies technology gaps through roadmapping and architecture planning exercises. Agency leaders work together to identify the appropriate workforce and approach for addressing recognized technology challenges. STMD collaborates with all internal stakeholders (primarily Science Mission Directorate and Human Exploration and Operations Mission Directorate) prior to initiating a development effort to ensure stakeholder needs are met and duplication of efforts does not occur. STMD has developed a "Mission Use Agreement" document that specifies the technology infusion path for technology utilization between STMD and Mission Directorates. STMD and AES have created MOU's for jointly funded and managed projects together. In addition to developing technologies that benefit human exploration, STMD also invests in crosscutting technologies that benefit science missions as well as the commercial space sector.

QUSTION 49:

How were the 11 STEM education consolidations at NASA identified? Did NASA identify them or did OMB? What evaluation criteria did NASA use as a basis for its decision for the proposed consolidation of those 11 programs?

ANSWER 49:

The America COMPETES Reauthorization Act of 2010 called for the establishment of a National Science and Technology Council (NSTC) Committee to inventory Federal STEM education programs and to develop a five-year STEM education strategic plan. NASA reported funding for these 11 programs in the 2011 STEM inventory but not in the 2014 update of the inventory, as these programs were either being sunset or consolidated. Some of these programs may be eligible to compete for funding managed by the Office of Education or the Science Mission Directorate. Education activities that have demonstrated results through rigorous evaluation would be expected to compete well in the NASA competition. For more details on the competition proposed under the STEM Education and Accountability projects, see the 2015 Congressional budget justification for the Office of Education and the March 2014 *Progress Report on Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education at* http://www.whitehouse.gov/sites/default/files/microsites/ostp/STEM-ED_FY15_Final.pdf).

QUESTION 50:

Why does NASA want to move education funding out of the mission directorates? What does this mean for educational outreach currently performed in the mission directorates? How will NASA address concerns from the community that the key scientists working to teach students about human spaceflight will no longer be first in line to do so?

ANSWER 50:

The Budget maintains a strong commitment to STEM education through its proposed Government-wide STEM reorganization. This proposal creates a more cohesive framework for delivering STEM education to more students and more teachers more effectively; supports the goals of the Co-STEM Strategic Plan; and is designed to enable more strategic investment in STEM education and more critical evaluation of outcomes. The Budget focuses efforts on the five priority areas identified by the Strategic Plan: P-12 instruction; undergraduate education; graduate education; broadening participation in STEM to women and minorities traditionally underrepresented in these fields; and STEM learning activities that typically take place outside of the classroom.

With that vision in mind, the Budget consolidates some NASA education activities in an effort to reduce fragmentation within NASA and across the Federal government. Through a more streamlined portfolio managed by the Office of Education, NASA will be able to focus education efforts around the core priority areas in the STEM Strategic Plan and support the goals of making STEM efforts more accessible to students, teachers, and institutions that need it most, using evidence-based approaches to inform funding and programmatic decisions.

Consolidated programs may be eligible to compete for funding managed by the Office of Education or the Science Mission Directorate. Education activities that have demonstrated results through rigorous evaluation would be expected to compete well in the NASA competition.

To excerpt and abbreviate from the NASA FY 2014 strategic plan, NASA will continue to *"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."* Our education programs will continue to develop and deliver activities that support the growth of the Nation's STEM workforce and inspire and educate the public. We will continue to engage and involve the public and other stakeholders (including key scientists) in our activities, and work to build an open, transparent and participatory organization. (For additional process details see pages 34-35 at: http://www.nasa.gov/sites/default/files/files/2014_NASA_Strategic_Plan.pdf.)

Additionally, the NASA Education Coordinating Council (ECC), established in FY 2012, will continue proven strategic direction and practices based on prior years NASA education consolidations. During earlier consolidations the ECC made two recommendations that propelled the Agency towards a streamlined education portfolio through:

- identifying lower priority activities to reduce or consolidate, and
- allowing for the expiration of existing contracts, cooperative agreements, and grants (i.e., sun-setting).

To minimize disruption to Mission Directorate stakeholders, NASA Education anticipates natural sunsetting (e.g., the end of grant or cooperative agreement

performance period, end of an undergraduate or graduate student's multi-year scholarship or fellowship, etc.) for most formal and informal activities. Finally, it is also expected that all Mission Directorates will continue, as budgets permit, to do outreach activities that did not meet the OSTP STEM inventory definitions for an "education program."

QUESTION 51:

Why was the GLOBE program the only education program explicitly noted to continue receiving funding from a specific mission directorate (Science)? Does this imply that Earth Science education is more important than other science disciplines?

ANSWER 51:

With 109 active Government-to-Government bilateral international agreements and 132 partnerships within the U.S. in place, the GLOBE program is a successful, long-standing international program with global reach and high visibility both in foreign countries and with U.S. federal Agencies, including the State Department. Its subject matter—the Earth system and environmental education—is wholly contained inside SMD's Earth Science Division. There is no intended implication of relative importance with respect to other SMD science areas.

QUESTION 52:

The NASA's FY 2015 Congressional Budget Justification states that, "NASA will make available its unique assets, such as the International Space Station to STEM education programs Government-wide on a reimbursable basis in order to enhance their effective reach to students and educators." Who will make the decisions regarding which STEM programs from other agencies will have the opportunity to utilize NASA assets? Will NASA STEM programs get priority?

ANSWER 52:

NASA Headquarters has a new Partnership Council that reports to the NASA Deputy Administrator and sets policies for the use of NASA assets, including their use for STEM Education, by partners whether they are federal or private entities. The Associate Administrator for Education then implements these decisions regarding which STEM Education programs from other Federal agencies will have the opportunity to utilize NASA assets. NASA also will continue internal consolidation of education functions, assets, and efforts into the coordinated STEM Education and Accountability Projects (SEAP). This will include on-going review to incorporate the most meritorious functions, assets and efforts of Mission Directorates into the SEAP.

The Education Coordinating Council (ECC) will continue to evaluate and provide guidance regarding NASA investments in STEM education to ensure the most effective NASA assets are made available to support the Nation's STEM education priorities. In terms of priority for NASA STEM education programs, NASA will

conduct a competition across mission directorates and NASA centers to identify the highest priority STEM projects and activities. Potential applicants and recipients include projects and activities previously funded by ARMD, HEOMD, and NASA Centers. Once projects and activities have been selected, consistent with existing NASA practices, NASA will award any education cooperative agreements, grants, and contracts through competitions.

QUESTION 53:

How will the $15M for STEM funding in the Science Mission Directorate be distributed across science disciplines? Who in the mission directorate will decide which education programs are funded? Since Earth Science is already receiving education funding through the GLOBE program, does this mean Earth Science will be funded more than other disciplines?

ANSWER 53:

Distribution of funding is to be determined across science disciplines, based on awards. NASA will release a cooperative agreement notice for SMD science education no later than the first quarter of 2015. The SMD Associate Administrator (or his designee) will make selections by the end of FY 2015. The GLOBE program, also funded through competitive means, is not expected to affect the relative distribution of resources among SMD's four divisions.

QUESTION 54:

Nothing motivates kids to study math and science like space exploration. On what basis did you find NASA's STEM education initiatives to be ineffective and in need of cutting in both FY 2014 and FY 2015?

ANSWER 54:

The Budget reflects an effort to balance priorities and programs across NASA within a constrained budget environment. Additionally, the Budget consolidates some NASA education activities in an effort to reduce fragmentation within NASA and across the Federal government. Through a more streamlined portfolio managed by the Office of Education and in partnership with other agencies, NASA will be able to focus education efforts around the core priority areas in the Federal Co-STEM Strategic Plan and better support the goals of making STEM efforts more accessible students, teachers, and institutions that need it most, using evidence-based approaches to inform funding and programmatic decisions.

QUESTION 55:

The NASA budget request includes a $16M cut to the National Space Grant College and Fellowship program, setting funding for the program at $24M. Space Grant is at work in all fifty states and rated highly effective in many states. The Administration proposed similar cuts last year but Congress funded the program at $40M. Why was Space Grant singled out for such a large budget cut again?

ANSWER 55:

The request for Space Grant was designed to enable NASA funds to reach diverse institutions and stakeholders in every state. As explained in the budget narrative: "NASA solicits Space Grants through full and open competition for proposals accepted from Space Grant consortia in each state, Washington D.C., and the Commonwealth of Puerto Rico . . .. Awards are typically for five years." (EDUC-14) Space Grant is integral to the FY 2015 request of $88.9M; a $5.3M or 6 percent decrease from the FY 2014 President's Budget Request ($94.2M) and the FY 2014 Effective Planning Level ($116.6M). The full FY 2015 request includes the following

- $24.0M for Space Grant, a nationwide network of colleges, universities, and other organizations that provide NASA space-related opportunities to students, educators, and the public;
- $9.0M for EPSCoR, which provides competitive research opportunities to institutions in targeted states;
- $30.0M for Minority University Research & Education Project (MUREP), which provides competitive NASA research and study opportunities to students of underserved and underrepresented groups and competitive opportunities to enhance the research and technology capabilities of Minority Institutions; and,
- $26.1 M for STEM Education and Accountability Projects (SEAP), which provide competitive opportunities, foster innovative education efforts at NASA Centers and through grantees, and formal evaluation activities.

The NASA request allocates the majority of funds to two projects that emphasize competitions and that are open to institutions and stakeholders beyond the Space Grant Consortia. The STEM Education and Accountability (SEA) program's two projects, MUREP and SEAP, have competitions that are open to minority serving higher education institutions, informal education institutions, non-profits, NASA Centers, etc. Space Grant's competitions, however, are limited to 52 consortia and the result has been that some of the same institutions have been funded annually by NASA for 25 years. The FY 2015 request for Space Grant *resets*, at a slightly lower level, and *recommits* NASA to baseline annual awards for essential funding for each consortium.

QUESTION 56:

For years, the Science Mission Directorate (SMD) had a policy that one percent of each mission's budget should be allocated to education and public outreach activities. As part of the Administration's ongoing efforts to reorganize federal science, technology, engineering, and mathematics (STEM) education programs, that policy has been terminated.

QUESTION 56a:

What are the benefits of this proposal for NASA and for the overall federal STEM education effort? What might NASA lose?

ANSWER 56a:

The FY 2015 budget request recommends $15M, plus an additional $6M for GLOBE, to support the most effective science education activities within NASA's Science Mission Directorate (SMD), while encouraging more cohesion and integration, both within SMD, within NASA, and across other external organizations. This dedicated funding for SMD recognizes the important role that NASA's science content and science experts play in inspiring students, teachers and the public about science and in particular, STEM careers. It also ensures that funding will go towards the most meritorious proposals, rather than be allocated through automatic set-asides to existing programs.

QUESTION 56b:

What are the goals of the proposed change? If better program evaluation is one of the goals, please describe how SMD-funded education programs are evaluated. How do those evaluations compare, in both methodology and conclusions, with evaluations of STEM education programs at other agencies?

ANSWER 56b:

In response to the 2013 NSTC CoSTEM *Federal STEM Education 50 Year Strategic Plan*, SMD will continue to support and collaborate with other agencies in the priority areas identified in the plan to: 1) improve STEM instruction; 2) increase and sustain engagement in STEM; 3) enhance STEM experience of undergraduate students; 4) better serve groups historically underrepresented in STEM fields; and, 5) design graduate education for tomorrow's STEM workforce. SMD remains focused on realizing the unique contribution NASA science makes towards meeting the Nation's education needs and on enhancing the public's understanding of science. In preparing America's future workforce, many professional development opportunities are made available by NASA that are firmly rooted in the science and technology of NASA science.

The fragmented nature of NASA education programs in the pre-STEM consolidation days made it difficult to assess the overall effectiveness of NASA's education portfolio and to determine whether the agency was supporting the most meritorious STEM education activities. The new consolidated framework for SMD STEM education will make it easier to develop centralized, rigorous evaluations of STEM efforts across SMD. While a consolidated listing of evaluation reports can be found at http://www.nasa.gov/offices/education/performance, NASA SMD has also enlisted the National Research Council Space Studies Board to provide feedback on how to improve evaluation and science educational restructuring efforts. A workshop will be held in Washington DC on December 3-4, 2014. Additional details can be found at http://sites.nationalacademies.org/ssb/CurrentProjects/SSB_152563.htm.

QUESTION 56c:

What has been the reaction to the termination of the one-percent policy among SMD-funded scientists and participants in SMD-funded education activities?

ANSWER 56c:

Given that the one percent policy has been in effect since 1993, the change in policy has generated concern from the science community. It is our expectation, however, that the science community will continue to be able to participate in SMD STEM activities under the new consolidated STEM framework. More details on SMD's new education approach will be released soon.

QUESTION 57:

In addition to its $17.461B budget request for FY 2015, NASA would receive $886M under the Administration's proposed OGSI. Congress is familiar with the usual two-way prioritization process, by which programs and projects are either in the budget, or not. Please help us understand the three-way process this year, with some activities funded in the regular budget, some funded in the OGSI, and some in neither.

a. If an activity just missed the cut for inclusion in the regular budget request, was it automatically a candidate for the OGSI?
b. Should Congress conclude that every activity not included in either the regular budget or the OGSI is of lower priority than all the activities included in the OGSI?
c. Military services sometimes submit "unfunded priorities" lists with their budget requests.[10] Should Congress direct Mission Directorates to submit a similar package of second-tier priorities, like the OGSI, every year?

ANSWER 57:

While the FY 2015 budget request reflects the levels set by Congress in the Bipartisan Budget Act of 2013, the budget request also proposes additional investments to support both domestic and security investments that reflect the President's priorities to grow our economy and create opportunities.

By providing an additional $885.5M for NASA, the Opportunity, Growth, and Security Initiative will support increased progress in our Science, Aeronautics, Exploration, Space Operations, Space Technology, Construction of Facilities and Environmental Compliance Restoration, and Education objectives.

The items selected add capability or value to the existing core activity. By definition the core activity in the budget is of a higher priority. However items listed in the OGSI either accelerate existing activities, extend operational lifetimes

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[10] See, for example, National Defense Authorization Act for Fiscal Year 2013 (P.L. 112-239), Section 1003.
51 U.S.C. 30103(c)

of missions, enable a higher level of development or research, and/or reduce development risk. Examples of this are listed below:

- Science: Funds the OCO-3 mission, accelerates funding for PACE and WFIRST/AFTA missions, supports extending missions in Planetary Science and Earth Science, and advances Research and Analysis and Power System Development;
- Aeronautics: Enables further development in advanced propulsion concepts development, low-altitude airspace and unmanned aerial system, and research to enhance Computational Fluid dynamics;
- Exploration: Reduces development risk for new spacecraft, including SLS, Orion, and Commercial partners;
- ISS: Maximizes the research potential of ISS over its extended lifetime, by ensuring availability of transportation services;
- Education: Supports increased competitive funding for STEM education and Accountability projects;
- CECR: Enables the building of the LaRC Measurement Sciences Laboratory which will facilitate aeronautics, space and science research and development; and,
- Space Technology: Provides support to a number of cross cutting initiatives providing further development in areas such as closed-loop life support systems, advanced robotics, composite structures, small spacecraft, and advanced manufacturing technologies.

QUESTION 58:

If SOFIA was a priority for NASA, why wouldn't it be included on a list of priorities for funding under the Opportunity, Growth, and Security Initiative?

ANSWER 58:

SOFIA did not make the list for OGSI investments due to its high annual operating cost and higher priorities within the NASA Science portfolio.

QUESTION 59:

NASA is required by law to include estimated budgets for the next five years in its annual congressional budget justifications.[11] In the past four budgets (since FY 2012) NASA has labeled the out-year amounts as "notional."

a. Does NASA have non-notional out-year budget estimates for its own use in program planning and project management?
b. If so, why are those amounts not provided in NASA's congressional budget justifications, so that Congress can be fully informed about the future implications of its funding decisions?
c. If not, how can NASA effectively plan multi-year programs and manage large multi-year projects, without realistic funding projections for future years?

[11] 51 U.S.C, 30103(c)

ANSWER 59:

Given the uncertainty in the Federal budget environment NASA has been planning notional levels for its outyears at the total agency level and at the account level. However, the budget is formulated from the bottom up at the required level to meet the lower level project goals and objectives. The life cycle costs associated with many NASA projects are highlighted in the NASA budget justification as firm commitments through every year.

QUESTION 60:

Have any other agencies volunteered to pay for the potentially underfunded accounts like SLS, Orion, SOFIA, construction, aeronautics, or Commercial Crew?

ANSWER 60:

No other Federal agency has volunteered to pay for the NASA programs identified in the question.

QUESTION 61:

NASA is struggling with the protection of sensitive information. Last year this Committee learned of inappropriate access granted to a foreign national at the Langley Research Center. Earlier this year, the National Academy of Public Administration called into question NASA's efforts to control foreign national access. Earlier this year, the NASA Inspector General issued a report critical of the casual treatment of sensitive information at the Ames Research Center. In the coming weeks, the Government Accountability Office will release a report on the Agency's handling of export-controlled information. All of these external reviews point to a similar problem. NASA's conflicting missions to broadly share scientific research and protect sensitive information present the agency with a paradox that it is currently struggling with. I worry that absent real reforms by the agency, NASA may be leaking our nation's prized aerospace technology. Please outline the step you are taking to ensure this is not the case.

ANSWER 61:

NASA takes the responsibility of securing sensitive and export-controlled information at its facilities and within its IT systems very seriously and is working to implement all of the recommendations from several external audits and reviews. Recognizing the growing threat aimed at government agencies by hostile nation-states and foreign adversaries, the NASA Administrator has already directed a number of actions to further secure sensitive and export-controlled information at NASA facilities and within its IT systems and to enhance overall security. The Government Accountability Office (GAO) report published in April 2014 complements recent reviews conducted by the NASA Office of the Inspector General (OIG) and the National Academy of Public Administration (NAPA), which provided its findings to the NASA Administrator in January 2014. The NASA

responses to the GAO, OIG, and NAPA recommendations are assisting in our continuing efforts to enhance all aspects of our foreign national access management, information technology security, access to sensitive information, and NASA's export control compliance program. The GAO report made seven recommendations to the NASA Administrator intended to ensure consistent implementation and improve oversight of NASA's export control program. NASA has accepted all seven of these recommendations and is in the process of implementing those recommendations. The NAPA report provided 27 findings and recommendations to improve foreign national access management, IT Security, export control, counterintelligence, and organizational functional relationships. On March 10, 2014, NASA established the Foreign National Access Management Program to address findings within the NAPA report in a systematic and coordinated approach across the Agency. NASA has provided a response to all of the NAPA findings and recommendations and is taking a risk-based approach to addressing them.

NASA works constantly to ensure that its IT systems and associated components are safeguarded from attack, assessed against stringent Federal and Agency security requirements, and continuously monitored to mitigate unauthorized intrusion. In whole, NASA concurred with all of the recommendations and will focus on meeting the intent of the findings.

QUESTION 62:

How did NASA come to the conclusion that the Measurement Science Laboratory, scheduled to begin construction this year, and costing nearly $90M, was not worthy of moving forward? How was this investment weighed against other construction projects?

ANSWER 62:

The Langley Research Center (LaRC) Measurement Science Laboratory will modernize technical capability strategically important to NASA. The project is included as part of the President's Opportunity Growth and Security Initiative in FY 2015. In FY 2014, the Institutional Construction of Facilities (CoF) program was funded at $82M below the President's request. As a result, NASA had to slip all CoF repair-by-replacement projects, specifically slipping the Marshall Space Flight Center (MSFC) Office Building 4221 project from FY 2014 to FY 2015, impacting the content that could be accomplished in FY 2015. High risk repair projects, demolition and energy savings projects were also deferred.

NASA must weigh the importance of performing urgent facility repairs to existing facilities, which may impact missions, against making progress on its strategic plan to modernize its core capabilities over time. NASA's facility strategy is to renew and modernize its facilities to sustain capabilities, and accommodate those capabilities in the most efficient facilities set practical. NASA balances risk-reducing repair projects with projects that replace, modernize and consolidate core capabilities to ensure that the Agency can make progress toward its strategic goals while reducing near term mission risks.

NASA's FY 2015 budget includes projects that illustrate this balance. The budget includes capability modernization projects such as replacement and consolidation of the Johnson Space Center (JSC) Human Health and Performance Laboratories and replacement and consolidation of an MSFC office building that will reduce annual costs. In FY 2015, examples of risk mitigation projects include airfield repairs at the Wallops Flight Facility, a power systems upgrade at Kennedy Space Center, and replacing central compressors 1, 2 and 3 at the Langley Research Center.

QUESTION 63:

Does the current budget request include funding for the cleanup of the Santa Susanna Field Site?

ANSWER 63:

The FY 2015 President's budget request includes $15.4M for NASA cleanup-related activities at SSFL.

QUESTION 63a:

What level of cleanup is NASA planning to meet - background levels, levels imposed by the State of California on the federal government, or safe levels based on the future intended use of the land?

ANSWER 63a:

In 2007, NASA entered into a Consent Order with the California Department of Toxic Substances Control (DTSC) and other responsible parties to address environmental investigation and remediation requirements at the SSFL. Further, in 2010, NASA entered into an Administrative Order on Consent (AOC) with DTSC, which governs soil remediation work at the NASA-administered portion of the SSFL. In accordance with the terms of the AOC, NASA has agreed to remediate soils on the NASA property at SSFL to levels that comply with contaminant values developed by DTSC in a series of Lookup Tables. The Lookup Tables are established on the basis of local background values and method reporting limits that can be achieved by a laboratory for contaminants that do not naturally occur. From the inception of NASA's engagement in study, analysis, planning and implementation of remediation measures to address the soil and groundwater contamination at SSFL, the Agency's underpinning commitment has been to ensure an effective cleanup that protects human health and the environment.

QUESTION 63b:

What are the cost impacts-to NASA for each of these cleanup levels?

ANSWER 63b:

NASA considered a range of alternatives for its proposed soil remediation action at

SSFL, which are detailed in NASA's Final Environmental Impact Statement (FEIS) for Demolition and Environmental Cleanup Activities for the NASA-administered portion of the SSFL, issued on March 14, 2014. The cleanup action alternatives considered and evaluated would implement soil and groundwater remediation technologies to achieve various risk-based cleanup levels, specifically the Suburban Residential, Commercial/Industrial, and, Recreational use levels. In general, risk-based protocols are designated for each of the cleanup levels to help assess the possible ways in which people and animals could be exposed to soil and groundwater contaminants and the health risks associated with that exposure. These risk-based alternatives were eliminated from further consideration under the FEIS because they would not meet the requirements of the 2010 AOC.

Section 2.4 of the FEIS details each of the cleanup alternatives considered, and Table 2.4-1 provides a comparison of the estimated approximate costs and scope of excavation activity associated with each of the alternatives. Approximate soil remediation costs for each of the alternative cleanup actions, as presented in Table 2.4-1, follow:

Demolition, soil cleanup to Background level, and groundwater cleanup:	$200,000,000
Demolition, soil cleanup to Suburban level, and groundwater cleanup:	$79,640,000
Demolition, soil cleanup to Commercial/Industrial level, and groundwater cleanup:	$39,310,000
Demolition, soil cleanup to Recreational level, and groundwater cleanup	$26,690,000

NASA's FEIS is available to the public at the following internet website: *http://www.nasa.gov/agency/nepa/news/SSFL.html.*

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE

"An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2015"

Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Rep. Donna Edwards, Ranking Member, Subcommittee on Space

QUESTION 1:

Is there a rationale for the reduced funding proposed for the SLS and Orion MPCV program, as compared to the FY 2014 enacted levels? What SLS/Orion development activities will have to be delayed to accommodate the cuts? How confident are you that you will be able to meet the 2017 planned date for the first SLS/Orion flight test and the planned 2021 date for the first crewed flight test of the SLS/Orion system under the proposed FY 2015 budget levels?

ANSWER 1:

The President's FY 2015 budget request supports progress toward a first uncrewed test of the Orion and the SLS together, known as Exploration Mission-1 (EM-1) in FY 2018, with the first crewed mission of the two vehicles slated for FY 2021-2022. SLS, Orion, and EGS continue to progress through key flight tests and hardware development milestones, based on FY 2014 appropriations, toward Exploration Mission-1 (EM-1). SLS, Orion, and EGS will each hold key milestone reviews in 2014-2015; the outcome of these reviews will yield a clearer picture of schedule challenges associated with actual technical progress and anticipated funding levels.

QUESTION 2:

I am deeply concerned about the possibility of a premature selection of a Commercial Crew Transportation services provider and how that translates into reduced safety for our astronauts. The Aerospace Safety Advisory Panel recommended in its Annual Report for 2013 that competition be maintained until safety confidence is achieved. The ASAP stated:
"If NASA down-selects to one provider before the selectee has demonstrated that its design can meet the required level of safety, there is the ultimate potential that the provider may not be able to meet the requirements for a number of reasons, including cost. In such a situation, NASA will have little alternative but to either move the safety "goalposts" or to incur an overrun and/or schedule slip. If competition is maintained, NASA may have alternatives other than accepting a less-safe design, unnecessary higher costs, or late delivery."

Do you agree with the ASAP's conclusions? If you don't get the Opportunity, Growth, and Security Initiative funding, would you be willing to adjust the

program's schedule to allow you to maintain competition and reduce risk?

ANSWER 2:

Whether or not NASA receives Opportunity, Growth, and Security Initiative funding, the Agency will not compromise on the safety requirements for commercial crew transportation. In the event NASA does not receive the funding level proposed in the President's FY 2015 budget request, the Agency may have to look at schedule adjustments to the program. Maintaining competition for the Commercial Crew Program is an important consideration for U.S.-based crew transportation.

QUESTION 3:

How you make the tradeoffs between taking advantage of extending science missions and starting new missions?

ANSWER 3:

NASA uses the Senior Review process to make the tradeoffs between taking advantage of extending science missions and starting new missions. Senior Reviews are evaluations of the science productivity of operating missions to support an assessment, based on demonstrated science accomplishments, and the anticipated science value of an extended mission.

QUESTION 4:

As you know, the Wide-Field Infrared Survey Telescope (WFIRST) was selected as the highest priority of the most recent National Academies astronomy and astrophysics decadal survey. By all accounts, it offers the promise of delivering transformative scientific results. What are NASA's plans for WFIRST, and when might we expect a decision to proceed with its development?

ANSWER 4:

NASA has begun pre-formulation studies for WFIRST. At an appropriate time and subject to budget availability, NASA will consider approving a formal start for the WFIRST mission.

QUESTION 5:

What is the rationale for the continued cuts being proposed to NASA's planetary science program, especially in light of the work that NASA plans to undertake on a Mars 2020 rover and a potential mission to Europa as part of the FY 2015 budget request?

ANSWER 5:

The FY 2015 President's budget request includes a budget request for Planetary

Science of $1,280.3M. This request is part of a broader approach to maintain balance across NASA within a constrained fiscal environment, and to ensure that the President's FY 2015 budget request is consistent with available resources while still maintaining the highest priority science across the portfolio of Planetary Science programs.

This budget request fully funds development of InSight (Interior Exploration Using Seismic Investigations, Geodesy and Heat Transport), OSIRIS-REx (Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer), and the Mars Rover 2020, initiates a new Discovery mission, supports the production of planetary exploration enabling Plutonium-238 in partnership with the Department of Energy, provides for instrument contributions to ESA's BepiColombo, ExoMars and JUICE (JUpiter ICy moons Explorer) missions as well as continues development of a potential mission to Europa. Additionally, the FY 2015 budget request maintains support for planetary science technology and research awards.

QUESTION 6:

NASA's FY 2015 budget request proposes to significantly reduce NASA's STEM programs both within the Office of Education and in the NASA mission directorates. Does the purported benefit of government-wide STEM coordination and restructuring outweigh the detrimental effect of reductions being made to NASA's STEM programs? How can Congress evaluate the impact of sharp reductions in NASA's educational activities as well as measure the effectiveness of any coordination efforts among agencies?

ANSWER 6:

The Budget still maintains a strong commitment to STEM education through its proposed Government-wide STEM reorganization. This proposal creates a more cohesive framework for delivering STEM education to more students and more teachers more effectively; supports the goals of the Strategic Plan; and is designed to enable more strategic investment in STEM education and more critical evaluation of outcomes. The Budget focuses efforts on the five priority areas identified by the Strategic Plan: P-12 instruction; undergraduate education; graduate education; broadening participation in STEM to women and minorities traditionally underrepresented in these fields; and STEM learning activities that typically take place outside of the classroom.

With that vision in mind, the Budget consolidates some NASA education activities in an effort to reduce fragmentation within NASA and across the Federal government. Through a more streamlined portfolio managed by the Office of Education, NASA will be able to focus education efforts around the core priority areas in the Strategic Plan and better support the goals of making STEM efforts more accessible to the students, teachers, and institutions that need it most, using evidence-based approaches to inform funding and programmatic decisions.

Information on NASA Office of Education performance is available in agency performance reports, such as the Annual Performance Report and Annual

Performance Plan. Evaluations of specific programs are available at: http://www.nasa.gov/offices/education/performance/index.html#.U3T09_ldWAg.

In terms of measuring effectiveness of agency coordination efforts, the Administration has developed and is monitoring progress of a Cross-Agency Priority (CAP) Goal to improve STEM education by implementing the Federal STEM Education 5-Year Strategic Plan. CAP goals are a management tool used to accelerate progress on Administration priority areas where the coordination of multiple agencies is required to achieve the end result. For more information on the CAP STEM goal, including strategies, indicators, and milestones, please visit: http://www.performance.gov/node/3404?view=public#apg

Prior to the CoSTEM plan, agencies worked together on an ad hoc basis. A benefit of government-wide STEM coordination and restructuring has been increased coordination and information sharing across agencies through more formalized interactions, including interagency working groups aligned to the CoSTEM priorities and STEM Education CAP goal. Interagency working groups are focusing on the following areas:

1) Improve STEM Instruction (Co-Lead Agencies: Department of Education-ED and TBD);
2) Increase and Sustain Youth and Public Engagement in STEM (Co-Lead Agencies: Smithsonian Institution-SI and National Aeronautics and Space Administration-NASA);
3) Design Graduate Education for Tomorrow's STEM Workforce (Co-Lead Agencies: National Science Foundation-NSF and National Institutes of Health-NIH);
4) Enhance STEM Experience of Undergraduate Students (Co-Lead Agencies: NSF and TBD); and,
5) Better Serve Historically Underrepresented in STEM Fields (Co-Lead Agencies: National Science Foundation-NSF and National Institutes of Health-NIH).

Involvement with these CO-STEM interagency working groups is allowing NASA Education to make progress on NASA's 2014 NASA Strategic Plan, 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." So far in FY 2014, NASA has hosted, for each of the lead agencies--NSF, SI and ED-- interagency working groups (IWGs) sessions in three of the five priority STEM education investment areas. As a member of each of the five interagency working groups, NASA Education will join with other agencies to establish criteria that will evaluate the impact as well as measure the effectiveness of any coordination efforts among agencies of the Co-STEM coordination activities.

QUESTION 7:

During the question and answer session at the hearing, you referred to a Department of Education Century Communities and Learning program and a number of STEM partnership activities between NASA and other agencies and

organizations. Those partnerships would seem to argue for ensuring the stability of NASA's role through enhancing its education activities through partnerships, rather than a scaling-back of NASA's education activities though the reductions proposed in the FY 2015 budget request. What would be the impacts of the proposed cuts to NASA's education account on the types of education and outreach activities that you discussed at the hearing?

ANSWER 7:

The requested funding for the Office of Education is part of a broader approach to maintain balance across NASA within a constrained fiscal environment. Interagency partnerships such as the Department of Education and NASA pilot for the 21st Century Communities and Learning program allow NASA to leverage the resources and capabilities of other agencies to increase the reach of NASA programs. Through a more streamlined portfolio managed by the Office of Education, NASA will continue to support the goals of making STEM efforts more accessible to students, teachers, and institutions that need it most, using evidence-based approaches to inform funding and programmatic decisions, and strategically focusing education efforts around the core priority areas in the Strategic Plan.

Furthermore, NASA Education has embarked a new business model that leverages partnerships with other agencies to increase the reach of NASA programs. NASA and the U.S. Department of Education (ED) completed a pilot reimbursable Space Act Agreement that ran from the Fall 2013 through Winter 2014. This pilot aligned to the near term actions under the CoSTEM priority to increase and sustain youth and public engagement in STEM. The NASA-ED partnership supported STEM objectives within ED's 21st Century Community Learning Center (CCLC) program. NASA customized pre-existing NASA online STEM challenges and associated curriculum materials to align with 21CCLC objectives. NASA worked with three 21CCLC states Colorado, Michigan, and Virginia. (See also the NASA budget narrative on: EDUC-5)

As an ED blog explains: "The successful completion of the collaborative activity demonstrated two of the key goals of the federal Committee on STEM Education: increase student engagement in STEM experiences and implement more effective coordination among federal agencies with STEM education investments." See: http://www.ed.gov/blog/2014/01/working-together-to-build-tomorrows-stem-workforce/.

Currently, NASA Education is negotiating a Memorandum of Agreement with the National Institute for Food and Agriculture (NIFA) (an Agency within the US Department of Agriculture) where each agency will be responsible for costs associated with its participation in joint activities. One such activity is the 2014 National Youth Science Day Experiment that will explore the field of aerospace engineering. The University of Arizona developed the 2014 National Science Experiment: Rockets to the Rescue! National Youth Science Day took place on October 8, 2014.

Another current example of a no-exchange-of-funds partnership, but with the private sector, is between NASA and Honeywell and supports ***FMA Live! FMA Live!*** is a high-energy live show that features actors, hip-hop dance, music videos, interactive scientific demonstrations and video interviews with NASA scientists to teach Sir Isaac Newton's three laws of motion and universal laws of gravity. The name of the show comes from Newton's second law of motion: force = mass x acceleration. 2014 year marks the 10th anniversary of this innovative collaboration for educational outreach designed to ignite students' interest in STEM. More details about the show are available at: http://fmalive.honeywell.com/

QUESTION 8:

In response to a question from Congresswoman Bonamici on NASA's work on climate sensors that were formerly a part of the NOAA-funded JPSS program, you said that "we plan to take the two sensors, the two climate sensors, and they will actually become a part of the International Space Station." Please provide the details on the plans for NASA's work on the previous NOAA-JPSS climate sensors and how and when those sensors will become part of the International Space Station.

ANSWER 8:

Starting in FY 2014, NASA assumed responsibility for a suite of climate-relevant observations, intended to continue the 30 plus-year data record in ozone profiling, Earth radiation budget, and total solar irradiance. These measurements previously were to be implemented by NOAA with the Radiation Budget Instrument (RBI) and the limb soundings from the Ozone Mapping and Profiler Suite Limb profiler (OMPS-L), on NOAA's Joint Polar Satellite System 2 (JPSS-2) series, as well as the Total Solar Irradiance Sensor 2 (TSIS-2) instrument, flown separately.

NASA has awarded a contract for the RBI instrument and has provided funding to NOAA for procurement of the OMPS-Limb sensor as part of their procurement of the OMPS sensor for JPSS-2. NOAA and NASA have an agreement that NOAA will continue to accommodate RBI and OMPS-Limb. The agreement includes a provision for NOAA to fly a NASA-provided mass model if RBI is not available in time for the JPSS-2 launch. NASA plans to procure an instrument to make total solar irradiance measurements as a hosted payload in the JPSS-2 timeframe.

It is noted that NOAA plans to fly the Total and Spectral solar Irradiance Sensor FM-1 (TSIS-1) on the International Space Station (ISS) in 2017. This is not a NASA mission and NASA does not currently plan to fly the former NOAA climate sensors on the ISS.

QUESTION 9:

Please provide the total amounts of funding that the industry participants in the Commercial Crew Program have put into commercial crew-related development, to date, and the total amounts that NASA has contributed, to date, to commercial crew-related technology and development in funding to each of the companies,

and provide it for each program phase to date.

ANSWER 9:

	SNC	Boeing	Blue Origin	Paragon	ULA	SpaceX	Total
Total Payments to Providers for the Commercial Crew Program (CCP)	314.1	561.9	25.7	1.4	6.7	408.8	1,318.6
CCDEV1 (SAAs only)	20.0	18.0	3.7	1.4	6.7	-	49.8
CCDEV2 (SAAs only)	105.6	112.9	22.0	-	-	75.0	315.5
CCiCap (SAAs only)	184.5	427.0	-	-	-	330.0	941.5
CPC	4.0	4.0	-	-	-	3.8	11.8
Total Other Payments Supporting CCP							133.6
Human Rating Requirements							0.9
Other Management and Support							132.7
Total Payments Made Supporting CCP to Date as of April 30, 2014							1,452.3

By the time the Commercial Crew Integrated Capability (CCiCap) is completed, NASA's investment in the three rounds of Commercial Crew Space Act Agreements (CCDev, CCDev2, and CCiCap) will be $1.533B. Based on representations by the companies, our industry partners will have made an aggregate investment of approximately 20 percent. The actual aggregate investment of the partners may be higher to the extent that industry has absorbed cost growth associated with hardware development challenges and schedule delays. A further level of definition regarding any company's investment in the Commercial Crew Program would be proprietary to that company and is Sensitive But Unclassified information.

NASA has also provided an aggregate $29M to industry for the Certification Products Contracts. The corresponding partner investment is unknown, but the partners are believed to have contributed to this activity, as the generation of these products has proven to be even more significant than we or they anticipated.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE

"An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2015"

Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Rep. Mo Brooks, Vice Chair, Subcommittee on Space

QUESTION 1:

America's Reliance on the Russians for access to the International Space Station is of grave concern. While NASA's Commercial Crew Program provides one avenue in which to decrease that reliance, what specific measures are in place to ensure that the commercial assets that NASA is subsidizing for the Commercial Crew Program will remain available for government use in both the near and distant future?

ANSWER 1:

NASA is committed to launching U.S. astronauts aboard domestic spacecraft as soon as possible. Maintaining competition is the primary measure NASA is using to ensure domestic crew transportation capability is available for use in both the near and long term. Having multiple U.S. providers will ensure that NASA and the Nation receive the best value for future U.S.-based crew transportation to ISS and will protect NASA from being reliant on a single provider.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE

"An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2015"

Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Rep. Julia Brownley

QUESTION 1:

Many of my constituents are frustrated by the pace of the ongoing cleanup project at the Santa Susana Field Laboratory in Ventura County, which is partially administered by NASA. On March 14, NASA issued the final Environmental Impact Statement (EIS) for SSFL, and is expected to issue a Record of Decision within the coming weeks. I am pleased that the EIS reaffirms the agency's commitment to the full clean up and adherence to the Administrative Order on Consent (AOC) with the state of California.

ANSWER 1:

On April 25, 2014, NASA signed a Record of Decision (ROD) based on the Final Environmental Impact Statement for the Demolition and Clean-up Activities at Santa Susana Field Laboratory (SSFL). NASA's ROD and attached Programmatic Agreement Among the National Aeronautics and Space Administration, the California State Historic Preservation Officer, and the Advisory Council on Historic Preservation Regarding Demolition and Soil and groundwater Cleanup at Santa Susana Field Laboratory, Ventura County, California (Programmatic Agreement) are available at the following website:
http://www.nasa.gov/agency/nepa/news/SSFL.html.

QUESTION 1a:

How would the $75.5M in requested funding for NASA's Environmental Compliance and Restoration account support continued cleanup at SSFL? What the key goals for NASA to meet at the SSFL site in 2015?

ANSWER 1a:

NASA Environmental Compliance and Restoration (ECR) plans for FY 2015 are based on a prioritized, risk-based approach for incrementally addressing NASA's cleanup portfolio. Projects are ranked according to the relative urgency and the potential health and safety hazards related to each individual cleanup. As studies, assessments, investigations, plans, regulatory approvals, and designs progress, and as new discoveries or regulatory requirements change, NASA expects that program priorities may change.

NASA's ECR request for $75.5M in FY 2015 includes $15.4M for SSFL activities, which will support the continuation of groundwater characterization, demolition and feasibility studies and will begin the development cleanup implementation plans. NASA will also continue preservation and mitigation efforts established under the Programmatic Agreement.

QUESTION 1b:

The 2014 work in progress report in the President's budget request states that NASA expects to begin implementing the demolition of buildings this year. What is the status of these demolitions? What is the process in place for disposing of the materials resulting from the demolition process?

ANSWER 1b:

NASA is currently working to get contracts awarded for demolition activities. Contractors are planned to be onsite in the summer of 2014 and demolition startup by the fall. NASA's ROD details the mitigation measures and best management practices that the Agency will implement to reduce the magnitude of the impacts of the proposed demolition action. (See Table 6.1-1 of NASA ROD.)

QUESTION1c:

The 2014 Consolidated Appropriations Act decreased funding for NASA's Construction and Environmental Compliance and Restoration Account from $646.6M to $515M. How has this cut impacted clean up at SSFL and the agency's 2014 cleanup activities?

ANSWER 1c:

The FY 2014 Consolidated Appropriations Act decreased funding for NASA's Construction and Environmental Compliance and Restoration Account from $646.6M to $515M. This resulted in a reduction to the ECR program from $75.5M to $66.1M. In order to achieve the $9.4M reduction, two Center projects were directly impacted in FY 2014, with the following reductions: $7M at SSFL and $2.4M at NASA's White Sands Test Facility (WSTF) in NM.

The SSFL demolition project was reduced from $15M to $8M. The remaining $7M of demolition work is planned for FY 2015. There is no immediate impact to the SSFL cleanup program, as the remaining $8M will keep the SSFL project on schedule with the State of California regulators. At WSTF, the $2.4M project for installation of a photovoltaic system to power the existing remediation systems was deferred to FY 2015.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE

"An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2015"

Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Rep. Bill Posey

QUESTION 1:

Can you give us the status on the supply, inventory and availability of Pu-238, and any other nuclear fuel that may be needed for spaceflight?

ANSWER 1:

According to the Department of Energy a total of 35 kg (77 lbs) of Pu-238 isotope is available for NASA missions. Of that quantity, 17 kg is within specifications needed to produce heat sources for NASA's spaceflight radioisotope power systems. DOE indicates the balance of the inventory available for NASA use could be blended to increase the net amount available. In addition to this existing allocation, NASA is currently funding the Pu-238 Supply Project, which will establish a new capability to produce up to 1.5 kg of Pu-238 oxide (1 kg of isotope) per year.

NASA is also working with the Department of Energy to evaluate other potential fuels that may facilitate production of the higher amounts of power needed for human exploration missions than would be practical with Pu-238. But there is no plan to use any fuel other than Pu-238 for NASA missions at this time. DOE should be contacted for information regarding the status of the national inventory of special nuclear materials.

QUESTION 2:

How much Pu-238 do we currently have in stock right now?

ANSWER 2:

DOE has allocated to NASA a portion of the national inventory. See response to Question 1 for insight into the NASA share of the allocated inventory. NASA does not have information regarding any balance of inventory that DOE manages and DOE should be contacted for information regarding the status of the national inventory.

QUESTION 3:

How much time does it take to produce Pu-238? What are the costs associated

with this production?

ANSWER 3:

NASA has entered into the Pu-238 Supply Project to restart production with DOE. The concept demonstration phase began in 2011, upon receipt of first funding by NASA. At current funding levels, the project should reestablish a national production capability by approximately 2021. The cost range to complete this project and initiate production is estimated to be $85-125M. Actual production process times and costs have not yet been established as part of the Plutonium-238 Supply Project plan.

QUESTION 4:

Is a Thorium Reactor currently being employed, or considered, to produce Pu238 from U233?

ANSWER 4:

No. The Plutonium Supply Project at DOE performed an analysis of alternatives and chose mature, established processes, facilities, and technologies to produce Pu-238 cost-effectively based upon NASA's requirements and early need date.

QUESTION 5:

Are you aware of any stockpile of U23J in our national inventory, that can produce Pu-238 in a Thorium reactor, that is currently being considered for destruction?

ANSWER 5:

NASA does not have any knowledge concerning the inventory of U233. DOE should be contacted for information regarding the status of the national inventory of special nuclear materials.

NASA is aware of the concept of producing Pu-238 from a Thorium breeder-reactor, which uses U233; however, the Department of Energy has determined this technology to be at a very low level of maturity.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE

"An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2015"

Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Rep. Frederica Wilson

QUESTION 1:

As a former school principal and school board member I am deeply concerned about the proposed 24% cuts to the NASA education budget. These programs are essential for inspiring our nation's youth to pursue STEM careers. Can you please explain the rationale behind the proposed cuts to NASA Education programs? What impacts will these have? How can Congress evaluate the impact of sharp reductions in NASA's educational activities as well as measure the effectiveness of any coordination efforts among agencies?

ANSWER 1:

The Budget balances priorities and programs across NASA within a constrained budget environment and consolidates some NASA education activities in an effort to reduce fragmentation within NASA and across the Federal government. Through a more streamlined portfolio managed by the Office of Education, NASA will be able to focus education efforts around the core priority areas in the Strategic Plan and better support the goals of making STEM efforts more accessible to the students, teachers, and institutions that need it most, using evidence-based approaches to inform funding and programmatic decisions.

NASA continues to provide education resources to principals, teachers, parents, and school board members through the education pages on NASA.gov. Additionally, weekly the NASA Education EXPRESS newsletter lists the latest in NASA education opportunities. EXPRESS is sent to current subscribers, and posted to the NASA Blog page at http://blogs.nasa.gov/educationexpress/2014/05/.
NASA Education listserv sign up is: http://www.nasa.gov/education/express.

While the reduced funding level for NASA Education means reductions to or even elimination of some historic activities, NASA STEM education remains in alignment with the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Reauthorization Act of 2010. NASA's investments will continue to provide unique support for minority serving institutions and community colleges, which generally serve a high proportion of minority students and prepare them for study at four-year institutions. Some opportunities for k12 teachers, youth, higher education students and faculty, and public engagement in STEM are continuing through consolidation within the Minority University Research and Education Project or MUREP. MUREP funds

competitive opportunities though Education Opportunities in NASA STEM (EONS) focused on different CoSTEM priorities. Closing on 18 June, for example, is a competition focused on Educator Professional Development. See full announcement at:
http://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={246A0EB3-18BA-38B9-1AD3-AC096F5D9F83}&path=open

Information on NASA Office of Education performance is available in agency performance reports, such as the Annual Performance Report and Annual Performance Plan. Evaluations of specific programs are available at: http://www.nasa.gov/offices/education/performance/index.html#.U3T09_ldWAg.

In terms of measuring effectiveness of agency coordination efforts, the Administration has developed and is monitoring progress of a Cross-Agency Priority (CAP) Goal to improve STEM education by implementing the Federal STEM Education 5-Year Strategic Plan. CAP goals are a management tool used to accelerate progress on Administration priority areas where the coordination of multiple agencies is required to achieve the end result. Each of these goals has a Goal Leader who is a senior Administration official and is fully accountable for the success and outcomes of the goal. Success in these areas requires a new kind of management approach – one that brings people together from across and outside the Federal Government to coordinate their work and combine their skills, insights, and resources. For the description of the FY 2014 STEM Education CAP goal, including strategies, indicators and milestones, please visit: http://www.performance.gov/node/3404?view=public#apg

Prior to the CoSTEM plan, agencies worked on an ad hoc basis. Now the CO-STEM interagency working groups are creating professional networks that should enable NASA Education to make progress on NASA's 2014 NASA Strategic Plan, 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." So far in FY 2014, NASA has hosted, for each of the lead agencies--NSF, SI and ED--interagency working groups (IWGs) sessions in three of the five priority STEM education investment areas. In FY 2015, NASA OE will continue its dedication to the IWG-created infrastructure, policies and best practices led by the three convening agencies, NSF SI and ED. As a member of each of the five interagency working groups, NASA Education will join with other agencies to establish criteria that will evaluate the impact as well as measure the effectiveness of any coordination efforts among agencies of the Co-STEM coordination activities.

QUESTION 2:

One of the stated goals of the President's budget is "*strengthen science, technology engineering, and math (STEM) education in ways that both inspire and prepare the workers and citizens of tomorrow for this century's challenges.*" I am concerned about the level of participation and retention among women and minorities in science education and the STEM workforce. I noticed that this budget provides only flat funding for the Minority University Research and Education Program and

proposes to reduce mission directorate education activities by $15M. These seem like cuts in areas where we need funding the most. How does this budget prioritize the participation of women and minorities in STEM education and the STEM workforce?

ANSWER 2:

An overarching operating principle consistent throughout the portfolio remains the continued focus on making opportunities available to a diverse audience of educators and learners, including women, minorities, and persons with disabilities. Within a constrained budget environment, the Administration maintains funding for MUREP at $30 million, demonstrating continued commitment to the program.

Other examples of NASA support for increasing diversity in STEM education include the following:

In March 2014, NASA Education and all parts of NASA participated in various Women's History Month STEM events. Additionally, NASA Education and our cooperative agreement partners demonstrate year-round commitment by documenting and sustaining girls and others traditionally underrepresented through on-line resources both on NASA.gov and on private sites. For example, NASA's Office of Education launched dedicated pages entitled "NASA Women in STEM" during the 2014 Women's History Month that will be updated regularly at: http://www.nasa.gov/education/womenstem/#.U3pcLvldWAg

NASA Wavelength, an online digital library, featured a banner pointing to a selection of Science Mission Directorate-funded education products and are still posted at: http://nasawavelength.org/tags/girls-stem

Established by Congress in 1988 and implemented by the National Aeronautics and Space Administration, the National Space Grant College and Fellowship Program (also known as Space Grant) contributes to the nation's science enterprise by through research, education, and public service projects funded by NASA to network of 52 university-based Space Grant consortia. Women are well represented as consortia leaders and their names can be found at: http://national.spacegrant.org/index.php?page=space-grant-contacts.

In terms of attracting women consortia employ strategies like WISER: Women in Science and Engineering Research. WISER provides first-year women students at University Park with research opportunities and mentoring. It was created in 1993 as a means to retain women in the traditionally male-dominated fields of science and engineering. http://pa.spacegrant.org/wiser

Another example is Women in Science (WIS) Conferences in Laramie that began in 1998 as a partnership between the National Weather Service Office in and the Wyoming NASA Space Grant on. In May 2011, approximately 355 Wyoming students attended a full-day conference. The students visited science labs, met professors, and had the opportunity to visit with women scientists in a variety of career fields. More information at:

http://wyomingspacegrant.uwyo.edu/WomenInScience.asp

NASA also provides financial assistance (grants and cooperative agreements) beyond Space Grant Consortia to the Nation's Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs), Asian American and Native American Pacific Islander-Serving Institutions (AANAPISIs), Tribal Colleges and Universities (TCUs) and eligible community colleges as required by the four Minority Serving Institutions (MSIs) Executive Orders through MUREP.

NASA will continue to work closely with other Federal agencies in executing the Administration's STEM education objectives. The Agency aims to increase both the use of NASA resources and the availability of opportunities to a diverse audience of educators and students, including women, minorities, and persons with disabilities.

NASA will continue to support and collaborate with other agencies in the key areas identified by the Federal STEM Education Five-Year Strategic Plan: 1) improve STEM instruction and learning; 2) increase and sustain youth and public engagement in STEM; 3) enhance the STEM experience of undergraduate students; 4) provide STEM learning opportunities to groups historically underrepresented in STEM fields; and, 5) design graduate education for tomorrow's STEM workforce.

QUESTION 3:

Throughout its operational lifetime the International Space Station has been a scientific research station with the mission of producing meaningful research. Given that operations of the ISS have been extended through 2024 for the purpose of studying the impacts of spaceflight on the human body, what is your projection on when this research will lead to the necessary understanding to develop sufficient mitigation of radiation risks, bone and muscle loss, sustainable life support, behavioral health and other challenges and risks in sending humans to the surface of Mars and returning them safely to Earth?

ANSWER 3:

NASA's Human Research Program (HRP) maintains a comprehensive research plan, called the Integrated Research Plan (IRP), which includes both flight and ground experiments and facilities. The IRP is available via the Human Research Roadmap: http://humanresearchroadmap.nasa.gov/. The Integrated Research Plan lays out for the scientific community the expected progression of research and technology tasks intended to address critical questions that must be answered to quantify the risks or develop mitigation strategies for the risks as they relate to the overall exploration mission campaign plans. HRP research and technology activities that are performed on the International Space Station (ISS) are done so either because there are no effective ground-based analog environments to conduct the work on Earth, or the research activity needs the complete operational environment of spaceflight to validate the countermeasure or technology. The ISS is necessary to mitigate 22 of the 32 human health risks in the HRP portfolio. With the ISS 2024 extension, HRP will make great progress toward mitigating the

majority of exploration health and performance risks by 2024. In the event that not all risk areas have been mitigated by the end of ISS' operational life, NASA will assess the potential impacts and the best way to address them, given the available knowledge.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE

"An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2015"

Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Rep. Steve Stockman

QUESTION 1:

Administrator Bolden, you stated the urgency to end reliance on Russians by fully funding Commercial Crew's budget request, so we can presume that eliminating reliance on the Russians should be applicable to all of NASA.

QUESTION 1a:

Do we ever allow Russians to have full control over the International Space Station? It is my understanding we have done so when Johnson Space Center was shut down for hurricanes.

ANSWER 1a:

The ISS can be commanded through both the U.S. and Russian Mission Control Centers, and critical systems that are required to maintain a stable orbit – such as guidance, navigation and control, and communications – are multi-failure tolerant and have dissimilar redundancy across the U.S. and Russian elements.

NASA's Marshall Space Flight Center (MSFC) Payload Operations Center (POC) has coordinated scientific research carried out aboard the International Space Station (ISS) since 2001. The POC also acts as a Backup Control Center for Mission Control Center – Houston (MCC-H) in the event of a catastrophic event. While this is primarily a hurricane season (June to November) contingency, the POC can be activated in the event of the unanticipated and immediate loss of capability at MCC-H.

QUESTION 1b:

Because of the current crisis, does NASA have plans to curtail any Russian access or controls of ISS?

ANSWER 1b:

The ISS can be commanded through both the U.S. and Russian Mission Control Centers, and critical systems that are required to maintain a stable orbit – such as guidance, navigation and control, and communications – are multi-failure tolerant and have dissimilar redundancy across the U.S. and Russian elements.

NASA's Marshall Space Flight Center (MSFC) Payload Operations Center (POC) has coordinated scientific research carried out aboard the International Space Station (ISS) since 2001. The POC also acts as a Backup Control Center for Mission Control Center – Houston (MCC-H) in the event of a catastrophic event. While this is primarily a hurricane season (June to November) contingency, the POC can be activated in the event of the unanticipated and immediate loss of capability at MCC-H.

QUESTION 1c:

Do you have any fear that Russia could commandeer control of ISS if relations become more intense?

ANSWER 1c:

The success of the ISS program is based on the mutual dependence of all partners and clearly recognizes the unique contributions they each provide to the program. As such, it is in the interest of all ISS partners to continue our normal operational and programmatic cooperation and not to allow disruption of any of the activities that have maintained continuous human presence on orbit for over a decade.

If the current situation deteriorates such that there are indications that the ISS partnership might be affected, contingency planning by NASA related to the ISS must maintain the safety of the vehicle and of all crewmembers including Russian, American and other international partner astronauts.

QUESTION 2:

A rare Mars and Venus fly by opportunity in 2021 offers an incredibly inspiring stepping stone for future Mars landings. Is a Mars flyby an important stepping stone for a safe human landing on Mars, as was Apollo 8 an important stepping stone to Apollo 11's safe lunar landing? If America does not take advantage of this unique flyby opportunity in2021, the next similar opportunity would be a decade later. Therefore, would this Mars- Venus flyby opportunity accomplish this essential precursor to a human landing a decade earlier than has been envisioned; therefore helping to advance a human landing by many years? America built both Gemini and Apollo in the 8 years following President Kennedy's speech. Are there any technical challenges to a Mars-Venus flyby which America could not solve in the similar timeframe before 2021?

ANSWER 2:

NASA has studied proposals for a near-term Mars flyby with crew in the 2021 and 2023 timeframe. The SLS vehicle and Orion spacecraft would be required for such a high-energy mission. However, given the limited support capability of Orion, an additional Habitation Module would be required to extend life support functions (air, water, food, waste disposal, etc.) to enable the over-500-day mission duration. Continued development of the systems and biomedical knowledge necessary to

support deep-space exploration missions are ongoing on the International Space Station (ISS). The SLS and Orion currently in development have a planned first crewed mission of 21 days in FY 2021-2022 to the lunar vicinity. A 2021 mission to Mars represents significant challenges due to life support systems required, space radiation response, in-space habitat development, and the understanding of human psychology of being in a small spacecraft for over 500 days. Although it made sense to perform a fly-by of the Moon as a stepping stone to lunar excursions, a crewed flyby mission of Mars may not be the best way to advance Mars exploration. It is not clear that there is any significant benefit to future missions to Mars by performing a one-of-a-kind Mars fly-by. As NASA endeavors to pioneer deep space, initial missions of Orion and SLS -- including one to a redirected asteroid in distant, retrograde lunar orbit -- combined with the research on ISS will develop the foundation for longer journeys to destinations such as Mars beyond 2021.

QUESTION 3:

The JSC arc jet has reportedly just been closed. Is this a fact? If not, what is the projected date of closure?

ANSWER 3:

The JSC arc jet facility was closed in March 2014.

QUESTION 4:

Will the JSC arc jet facility be preserved as-is, apart from equipment sent to Ames; and be capable of being brought back into operation should the need arise in the future?

ANSWER 4:

The JSC arc jet facility is in the process of being abandoned in place, apart from spare parts inventory which was transferred to Ames in April 2014. The JSC arc jet facility buildings and infrastructure is currently scheduled for demolition in 2017. NASA will explore the possibility to accelerate the project within demolition budget constraints.

QUESTION 5:

Will anything at the JSC arc jet facility not being transferred to Ames be destroyed, removed, scrapped or otherwise be lost for potential use should future needs require reopening the facility?

ANSWER 5:

All equipment necessary for future operation of the former JSC capability has been relocated to or procured by Ames, and nothing relevant to future operations of the former JSC capability in the consolidated facility will be lost or destroyed.

QUESTION 6:

How much of the capabilities of the JSC arc jet will be duplicated at Ames? What specific capabilities would Ames' not be able to accomplish that JSC's was?

ANSWER 6:

The arc jet consolidation project has met every requirement specified by NASA HQ, JSC engineering management, and the Orion program regarding arc jet capability. All project schedules, milestones, and requirements were approved by review panels comprised of JSC engineering, Ames engineering, facility operations, and Orion program representatives. Although, as of May 2014, the arc jet consolidation project is still in progress, the arc jet equipment transferred from JSC to Ames is routinely operated at Ames and is conducting thermal protection material testing at the request of the Orion program. When all aspects of the arc jet consolidation project are completed, every capability formerly available at JSC will be available at Ames, in addition to other existing arc jet capabilities available at Ames that far exceeds the test capability formerly available at JSC.

QUESTION 7:

Will the Ames arc jet facility be sufficient and suitable for the development and testing of the unique heat shield for Orion which would be required for a Mars-Venus flyby mission?

ANSWER 7:

The Ames arc jet facility will be sufficient to meet all identified testing and certification requirements for Orion and other NASA missions.

QUESTION 8:

Deep space missions will only be enabled through critical and strategic technology development, such as high powered, solar electric propulsion. Administrator Bolden, relative to Solar Electric Propulsion, what do you/NASA consider or define as 'high powered,' in kilowatts?

ANSWER 8:

Measured by today's capabilities, NASA believes 30 to 50kW solar arrays beginning of life and 12-15kW per thruster to warrant the label "High Power."

These power levels are used as representative threshold values to define "high power" Solar Electric Propulsion (SEP). The largest autonomously deployed solar arrays operating in space today provides roughly half this power output, while the largest electric propulsion thrusters in operation today use roughly one third these power levels.

As your subsequent question points out, NASA and the National Research Council envision multiple missions enabled at these power levels and above. In fact, part of the rationale behind STMD's choice to develop a 50kW SEP for the Asteroid Redirect Mission (ARM), as opposed to, for example, developing an alternate standalone high power SEP demonstrator, was that the ARM mission propulsion requirements crossed the threshold for an advanced high power SEP capability that could later extend to large 300kW to 600kW systems needed for future human exploration mission to destinations such as Mars. This decision was made on the advice of structures, power and electric propulsion experts confirming that testing and demonstration of the 50kW system would provide sufficient evidence to allow design and extensibility for these large human exploration systems.

Furthermore, after discussions and study of the current developments in the Nation's commercial spacecraft industry, NASA believes that it is possible to leverage investments and interest in high-power SEP technology currently under development by industry.

QUESTION 9:

The NRC, as well as others have stated the "high power goal" for solar electric propulsion technology development to be about 300kW. The President's budget specifically states that the ARM relies on 3 critical development activities with the development of "high power" solar electric propulsion as a necessity to enable the mission. Have all applicable technologies been assessed to compare and overall capability-the maximum power level?

ANSWER 9:

NASA asked the NASA Engineering and Safety Center (NESC) to conduct a trade study on possible propulsion options for the ARM mission in the summer of 2012. The study reviewed Hall and ion thruster development, magneto-plasma systems, and chemical propulsion systems. That study aligned with discussions with experts in the industry that suggested a Hall thrust system provided the needed thrust, efficiency and was at a technical maturity level consistent with the mission needs. It is the intent of NASA, however, to allow for the consideration of technologies during the acquisition process. Consistent with anticipated NASA's needs in high-power SEP, NASA has had an on-going technology development activity that focuses on developing three key SEP technologies to support an ARM mission and an eventual 300kW system:

Electric Propulsion Thrusters: Leveraging work by NASA and the Department of Defense, NASA is designing, fabricating and testing 12-15 kW magnetically shielded Hall Effect Thrusters. These thrusters would operate at approximately 3X the power level of the highest power level EP thrusters in operation today. The designs will incorporate the latest magnetic shielding concepts, which will protect the channel walls of the thruster and enable propellant throughput and life commensurate with the needs for ARM and other future NASA missions. For the ARM mission, the use of a cluster of 3 or 4 of these 12kW to 15kW EP thrusters provides one approach to achieving the needed thruster power, thrust and specific

impulse requirements. NASA recognizes that other EP thruster options also exist that may provide the needed 40kW to 50kW thruster power for ARM. The human exploration systems studies performed by NASA, and referenced in the question, examined the utility of a 300kW SEP system that would leverage a Hall based EP system with 30kw to 50kW per thruster. NASA has worked on designs for thrusters at these higher power levels in the past and continues experiments with engineering models to this day. These studies show a clear path to scale the current work conducted in support of ARM mission to larger power level thrusters. Alternative high power EP thrusters may also serve in future human class SEP systems.

Solar Array Systems: In early FY 2012, NASA recognized that the 'long-pole in the tent' of high-powered SEP was in the technology for deployable array structures. Space Technology selected two solar array system development contractors: ATK and Deployable Space Systems (DSS) to develop concepts for large autonomously deployable solar arrays scalable to 300kW power levels. Investment in solar array technology addressed the risk faced by both industry and NASA in achieving high-powered systems.

As part of the development effort, each vendor has designed, built and completed ground testing on engineering development unit solar array wings. These new arrays have three traits that represent significant departures from current arrays in use today: 1) The new autonomously deployable arrays have roughly half the structural mass of current arrays; 2) The new arrays pack in roughly 1/3 the volume during launch relative to state of the art arrays; and, 3) The arrays are easily scalable to high power levels including 300kW.

The new array technologies represented by NASA's developments will result in a transformation in the power systems of majority of future spacecraft both commercial and government. The structural mass reduction alone provides a compelling case for significantly improved affordability of future arrays and spacecraft. The reduced packaging volume is essential to allow for single launch approaches for very large power systems. Current commercial satellites have a roughly 30kW upper limit on deployable solar power due to the launch shroud constraints. The new arrays essentially removes this constraint on the commercial side, and allows a high-powered SEP tug with deployable arrays to use a single SLS launch (as oppose to difficult in-space assembly) for human exploration. Finally, the two new systems from ATK and DSS are inherently designed for scalability to 300kW.. Completion of the SEP demonstration on ARM will put NASA in position to develop the 300kW class array for future human exploration missions.

Power Processing Units (PPU): The transfer of electrical power between the solar arrays and EP thrusters requires a power processing unit. The fundamental purpose of this system is to adjust the voltage and condition the power produced by the solar arrays to levels that allow optimum performance from the EP thruster. Space Technology is supporting two PPU design approaches that mirror two different array voltage designs. Engineering Development Units (EDUs) will be completed this summer and placed in testing. One of the designs utilizes a higher input voltage of 300V (voltage of the power produced by the arrays) that improves the

efficiency and reduces the mass of the complete SEP system (current arrays typically use voltage of roughly 100V). The PPU chosen for the ARM mission, however, is dependent on the final decision associated with array voltage. Regardless of the choice, the work done at Glenn Research Center on these designs, the subsequent testing, and the utilization on the ARM mission will dramatically advance NASA towards the goal of developing a SEP system capable of operating at 300kW.

The fundamental take away from these answers should be that once proven, NASA's ARM SEP system doubles the power generation of today's on orbit capabilities and positions NASA to utilize SEP technology at even higher power levels in the future and positions the Nation's spacecraft industry to achieve higher power levels and additional capability. Along the way NASA is facilitating a transformation in solar power generation and electric propulsion capabilities for the benefit of wide range of government and commercial applications.

Appendix II

Additional Material for the Record

THE PLANETARY SOCIETY

PLANETARY.ORG

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Cong. Steven Palazzo
Chairman, Subcommittee on Space
House Committee on Science, Space, and Technology
2321 Rayburn
Washington, DC 20515

Cong. Donna Edwards
Ranking Member, Subcommittee on Space
House Committee on Science, Space, and Technology
394 Ford
Washington, DC 20515

Dear Chairman Palazzo and Ranking Member Edwards:

Enclosed is a statement for the record from The Planetary Society for your hearing on NASA's FY2015 budget, scheduled for Thursday, March 27. With over 40,000 dues-paying members, The Planetary Society is the largest independent, nonprofit space outreach and advocacy group in the world.

We strongly believe that NASA is a crucial investment in our nation's future and the future of all humanity. As detailed in our testimony, we are very concerned that the Administration and NASA have not made planetary science and solar system exploration a priority in its budgets for the past three years, including the FY2015 budget request. We commend the bipartisan, bicameral support that the Congress has provided to address the precipitous cuts and programmatic choices that have put planetary science on a path to decline.

We respectfully request that you include the enclosed statement as part of the official record for the upcoming hearing.

We strongly support the language in the House NASA Authorization bill, H.R. 2687, pertaining to NASA's Planetary Science Division, particularly section 321 and the authorized funding levels of $1.5 billion per year. Thank you for your support in this important endeavor.

Sincerely,

Bill Nye
Chief Executive Officer
The Planetary Society

Statement by
The Planetary Society

before the

Committee on Science, Space and Technology's
Subcommittee on Space
U.S. House of Representatives

Hearing: NASA's FY2015 Budget Request

The Planetary Society has serious concerns for the future of NASA's Planetary Science Division as proposed in the FY2015 NASA budget request. For the third year in a row, the White House has proposed cuts to the program that will ensure the decline of planetary exploration over the course of this decade. The core recommendation of the National Academy's planetary science decadal survey—the crucial balance of small, medium, and flagship missions, combined with steady research and technology funding—is not supported by this request, which is nearly $220 million below the recommended $1.5 billion per year needed to implement a program consistent with the intent of the decadal survey.

NASA's Planetary Science program has a clear direction provided by the *Visions and Voyages Planetary Science Decadal Survey* and has maintained a productive, successful, and unprecedented program of exploration throughout the past decade. The Curiosity rover is approaching the base of a 18,000-foot Martian mountain; the Cassini spacecraft has captured sunlight glinting off methane lakes on Saturn's moon Titan; New Horizons will fly by Pluto next year for the first time in human history. These are highly engaging, exciting, and compelling events delivered by NASA's planetary program. They inspire generation after generation of students and the public to embrace science and engineering. They dramatically demonstrate the United States' engineering and scientific prowess. But despite this, the White House has proposed cuts year after year that threaten the health of this program.

Previous congressional actions have mitigated the losses to planetary science that would have come about had the White House's original requests in FY2013 and FY2014 been enacted. But even with these partial restorations, the United States' scientific exploration of the solar system is approaching a nadir not seen since the 1980s. The number of new missions launching during the period covered by the current decadal survey has dropped by half compared to the previous decade [*see Tables 1 & 2*]. When the Cassini spacecraft at Saturn and the Juno mission at Jupiter end their missions in 2017, there will be no NASA missions exploring the outer planets for the first time since the 1970s. Decades of hard-earned capability and engineering know-how will be placed at risk just as Europe, India, Russia, and China are committing to solar system exploration.

Even if a new mission to the outer planets were selected tomorrow, the United States would still face a minimum six-year gap. The "fade to black" predicted by respected NASA veterans Bobby Braun and Noel Hinners[1] has come to pass. The question facing NASA and the Congress is how long they choose to make this period last.

The Administration's budget proposal ensures a long period of darkness. Based on statements within the budget document, the number of new planetary science missions in development dwindles to two (Mars 2020 and the next small-class Discovery mission) by 2016, the lowest level in decades [Figure 1]. While NASA officials have stated their intention to increase the cadence of the Discovery missions by the end of the decade, the budget makes no commitment to this effect. It also suspends one of the major components of a balanced planetary program: the medium-class "New Frontiers" mission line. If this occurs, exactly zero of the competitively-selected medium-class missions recommended by the decadal survey for 2013 - 2022 will be implemented. This represents a notable change in policy, as all previous budgets anticipated a new New Frontiers opportunity in 2016.

The House NASA Authorization bill (H.R. 2687) passed by the House Science, Space, and Technology Committee last July contains a clear policy (section 321) that would mitigate the length of this downturn, particularly by calling for NASA to return to the decadal recommendations of a Discovery-class mission every two years and a New Frontiers-class mission twice per decade. We strongly support section 321.

The Administration did take a tentative step towards a mission to explore Europa, which would help address the lack of outer planets exploration. Europa, the moon of Jupiter with a vast liquid water ocean, is a destination long sought by the scientific community. It ranked as the most important flagship mission in the first decadal survey and the second-most important in the current decadal survey. Last year's discovery of likely water plumes erupting from Europa's south pole only served to increase the moon's scientific importance. These plumes significantly lower the cost of performing initial analysis of Europa's water, as a spacecraft could far more easily fly through and collect plume samples instead of landing and boring through a thick ice sheet.

But the White House requests a mere $15 million to study a low-cost Europa mission concept, despite having received over $140 million in the past two years to advance the Europa Clipper concept mission from the Jet Propulsion Laboratory and the Applied Physics Laboratory, which had already reduced the cost of a major scientific mission by over 50% from the original decadal concept. To reduce it further, as NASA has indicated, raises serious questions of the scientific return possible from such a mission. We are all for cost-savings, but we must ensure that this once-in-a-generation opportunity to explore Europa achieves the preponderance of scientific goals as defined in the decadal survey, and sufficiently moves forward our understanding of Europa to the point where NASA could subsequently attempt a landing on the surface.

[1] *U.S. Planetary Science: Fading to Black.* Space News, April 22, 2013.

The timing for the Europa mission, not mentioned in the FY2015 request but stated by NASA officials as "mid-2020s," is also a concern. Again, we support the language in the House Science Committee's draft NASA authorization bill (Sec 321), which sets a goal for NASA of a 2021 launch of a major Europa mission.

The Administration's budget deserves praise for funding continued operations for several existing planetary science missions, notably the popular Curiosity rover on Mars and the long-lived Cassini orbiter at Saturn. Additionally, the request provides adequate funding to maintain the Department of Energy's Plutonium-238 infrastructure and restart program, which is crucial to continued access to destinations where solar power is unfeasible. We strongly support these decisions, and urge Congress to do so as well.

But the budget proposal does place the continued operation of two functioning planetary spacecraft at risk. Both the Opportunity rover and the Lunar Reconnaissance Orbiter are zeroed out in the base proposal, moved instead to the President's *Opportunity, Growth, and Security Initiative*. The Planetary Society believes in maximizing taxpayer value for NASA assets by continuing operations as long as missions remain scientifically valuable. We fully expect the upcoming senior review at NASA to validate the scientific returns of both missions, and strongly recommend that both continue operations whether or not the OGSI is passed.

The major NASA achievements in planetary exploration slated for FY2015—Curiosity at Mt. Sharp, New Horizons at Pluto, Dawn orbiting Ceres—represent what's great about the country. They are bold feats of engineering and scientific prowess. They are optimistic, each one faced immense challenges that were overcome by careful thought and planning. They engage the public with their bold feats of discovery. They are also all initiatives from the previous Presidential administration.

Spacecraft take time to design, build, and fly. We are not so much concerned for the health of the current set of missions (Opportunity and LRO are notable exceptions) so much as we are concerned for the health of the program going forward. NASA already faces the biggest gap in solar system exploration in decades, and has dropped its launch rate for this decade by half, but this can still change. Wise action by the Congress and a receptive Administration can embrace planetary science for what it is: a unique and hard-earned capability that is worth a small investment—$1.5 billion per year, less than 9% of NASA's total budget—to maintain a peerless program of exploration that inspires the country.

Addendum

Table 1. Missions launched/launching during Decadal Survey timespan of 2013 - 2022:

2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
LADEE MAVEN			InSight OSIRIS-REx				Mars 2020	Discovery 13	

Projected launch rate: 0.6 missions per year.

Table 2. Missions launched during the previous Decadal Survey timespan of 2003 - 2012:

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Spirit Opportunity	MESSENGER	MRO Deep Impact	New Horizons	Phoenix Dawn		Kepler		Juno Grail MSL	

Launch rate: 1.2 missions per year.

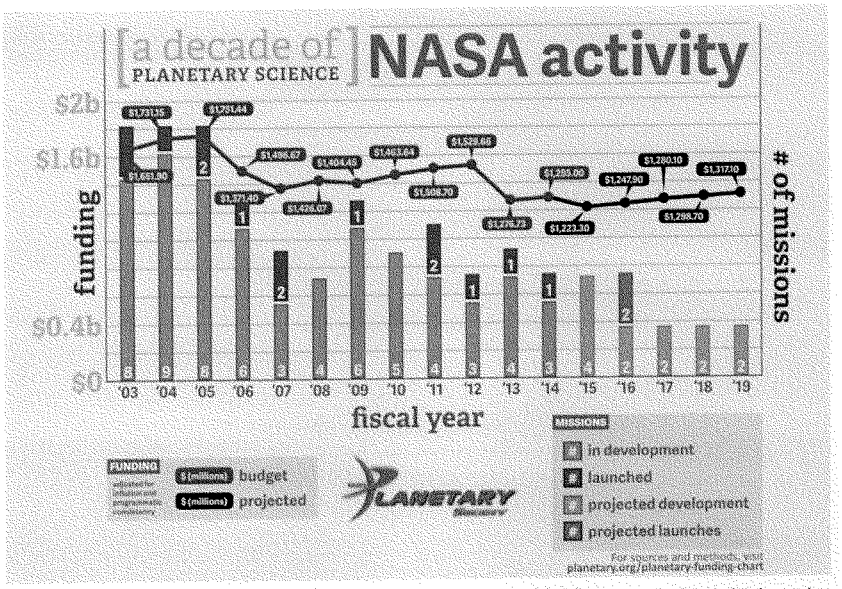

Figure 1: Funding level of NASA's Planetary Science Division from 2003 – 2019, adjusted for inflation and displaying the number of missions planned to be in development according to NASA Budget requests during this period. The average budget for 2003 - 2013 is $1.5 billion per year. Modifications to the budget have been made to preserve programmatic consistency. Note that by the end of the decade the Division is working on only two new missions while maintaining an aging set of spacecraft, and funding Pu-238 development, scientific research, NEO detection, and instruments on foreign missions. Raw data and methods are available at http://planetary.org/planetary-funding-chart

Note: funding projections suggest that the Discovery 14 mission could begin development in FY18 or FY19, though this is unstated in the budget request and therefore not represented here.

ADDITIONAL RESPONSES SUBMITTED BY THE HON. CHARLES F. BOLDEN, JR.

Material requested for the record on page 32, line 679, by Representative Edwards during the March 27, 2014, hearing at which Administrator Bolden testified.

NASA contracted with Booz Allen Hamilton to perform an Independent Cost Assessment (ICA), which was completed in the Fall of 2012, and provided to the Committee. Please note that the ICA stated in its analysis that the "Commercial Crew Program's mid-2017 first launch date of a certified system is achievable based on independent analysis assuming they receive sufficient and stable funding." The Agency will be in a position to further refine its cost estimates after it makes CCtCap awards in September 2014. After the awards are made, we will keep the Committee informed as we continue to refine our estimates.

Material requested for the record on page 63, line 1436, by Representative Posey during the March 27, 2014, hearing at which Administrator Bolden testified.

NASA and the Department of Energy (DOE) are working together on the Plutonium Supply Project to restart domestic production of Pu-238. The concept demonstration phase began in 2011. Significant progress is being made and at current funding levels, the project should reestablish a national production capability by approximately 2021.

DOE has provided NASA with an identified allocation of Pu-238 available for NASA spaceflight use. The allocation identifies a total of 35 kg (77 lbs) of Pu-238 isotope. Of that quantity, 17 kg is within specifications needed to produce heat sources for NASA's spaceflight radioisotope power systems. DOE indicates the balance of the inventory available for NASA use could be blended with new material to increase the net amount available.

NASA is not aware of any Pu-238 being considered for destruction or being used for other reasons; DOE, as the responsible agency, should be contacted for information regarding the status and use of the national inventory of special nuclear materials.

Material requested for the record on page 70, line 1612, by Representative Schweikert during the March 27, 2014, hearing at which Administrator Bolden testified.

Since its inception, the International Space Station (ISS) has been designed so that it could be operated without crew onboard (assuming no system anomalies), in a crew-tended mode, or permanently crewed. The nominal operational mode is to be permanently crewed to maximize research throughput and repair systems when anomalies occur. Critical systems that are required to maintain a stable orbit, such as guidance, navigation and control, and communications, are generally two-fault tolerant and have dissimilar redundancy across the U.S. and Russian elements. Under most conditions, the crew is not required to operate the Station in orbit, but the crew is required to maintain the systems and effect repairs when failures occur. The on-orbit crew has a key role to play in maintenance of the systems aboard ISS, as astronauts can address anomalies and perform repairs to critical ISS systems – both inside and outside the vehicle. For example, in the summer of 2010, and again in December of 2013, a coolant pump module on the exterior of the Station failed. The module was critical to the full operation of the ISS, as it was used to move ammonia through the Station's external thermal control system, enabling the dissipation of heat that would otherwise force the shut-down of critical systems. Spacewalking astronauts were on hand to remove the faulty module and replace it with a new pump, thus ensuring continued nominal operations.

The plan for short-term de-crewing includes such items as closing module hatches, stowing equipment, configuring systems such as Environmental Control and Life Support System (ECLSS) for re-crewing, and providing additional cross-strapping between power and command and control systems. In addition, plans are also in place for long-term uncrewed operations in the remote event of an extended gap in crew transfer capabilities. These plans are codified in the Flight Rules and include such crew actions as reconfiguring elements and distributed systems, checking switch positions and re-setting limit set-points, topping off or draining fluids, inspecting seals, disposing of batteries, repositioning equipment necessary to re-crewing, and environmental sampling. These procedures have been established for every domestic and international element in the ISS configuration, and ensure that the ISS will be configured appropriately to enable uncrewed operations as well as the eventual return of the crew.

ISS can be operated without a crew onboard, however a launch-on-need crew capability would be needed to enable emergency time-critical repairs. Failures in selected systems would need expedited repair to ensure that attitude control and reboost capability is not lost – as was required last December for the cooling pump. Attitude control and reboost will be needed to safely deorbit ISS at end of life. Given the potential failures and when they could occur, a launch-on-need posture may result in more flights to ISS than are necessary today to maintain permanent presence. An alternate approach would be to schedule crew visits periodically to ISS at least once per year. Given the elevated risk of losing the ISS over a six-month period of unmanned operations and potential damage or injury that might be caused by an uncontrolled atmospheric entry, NASA does not recommend operating ISS without a crew permanently on board. ISS could be reopened after

having been uncrewed, provided critical systems – such as attitude control, etc. – were maintained during the period without crew.

Material requested for the record on pages 78, line 1817, by Representative Palazzo and Edwards during the March 27, 2014, hearing at which Administrator Bolden testified.

By the time the Commercial Crew Integrated Capability (CCiCap) is completed, NASA's investment in the three rounds of Commercial Crew Space Act Agreements (CCDev, CCDev2, and CCiCap) will be $1.533B. Based on representations by the companies, our industry partners will have made an aggregate investment of approximately 20 percent. The actual aggregate investment of the partners may be higher to the extent that industry has absorbed cost growth associated with hardware development challenges and schedule delays. A further level of definition regarding any company's investment in the Commercial Crew Program would be proprietary to that company and is Sensitive But Unclassified information.

NASA has also provided an aggregate $29M to industry for the Certification Products Contracts. The corresponding partner investment is unknown, but the partners are believed to have contributed to this activity, as the generation of these products has proven to be even more significant than we or they anticipated.

Material requested for the record on pages 79, line 1843, by Representative Edwards during the March 27, 2014, hearing at which Administrator Bolden testified.

Please see "Pioneering Space: NASA's Next Steps on the Path to Mars," at the following website for details about NASA's deep-space human exploration plans: http://go.nasa.gov/1mL91Il

This document conveys the current state of planning. As indicated in the document, NASA continues to develop its plans for deep-space exploration and pioneering in dialog with our partners and stakeholders.

Material requested for the record on page 84, line 1972, by Representative Brooks during the March 27, 2014, hearing at which Administrator Bolden testified.

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