AN OVERVIEW OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION BUDGET FOR FISCAL YEAR 2014

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRTEENTH CONGRESS

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April 24, 2013

AN OVERVIEW OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION BUDGET FOR FISCAL YEAR 2014

WEDNESDAY, APRIL 24, 2013

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

The Subcommittee met, pursuant to call, at 2:00 p.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
RANKING MEMBER

Congress of the United States
House of Representatives
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6301
(202) 225-6371
www.science.house.gov

Subcommittee on Space

An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014

Wednesday, April 24, 2013
2:00 p.m. to 4:00 p.m.
2318 Rayburn House Office Building

Witness

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

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

An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014

Wednesday, April 24, 2013
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

Purpose

The purpose of the hearing is to review the Administration's FY2014 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 17,600 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 April 10, 2013, a full two months later than federal law mandates.[1] For FY2014 NASA is requesting $17.715 billion, a decrease of $55 million from FY2012. The request is $733 million less than amounts received in FY2011; and is approximately $1 billion less than amounts received in FY2009 and FY2010. For each of the

[1] The Budget and Accounting Act of 1921 (U.S.C. 1105 (a)) 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." President Obama submitted his budget on April 10, 2013 which is 65 days passed the required date of submission.

Fiscal Years 2015 – 2018, the budget topline request is the same as FY2014, though the agency considers the out-year numbers to be "notional."[2]

Budget Request

Budget Authority ($ in millions)	Actual 2012	Estimate 2013	Request 2014	FY13 vs FY14	Notional 2015	2016	2017	2018
	17,770.0	17,893.4	17,715.4	(178.0)	17,715.4	17,715.4	17,715.4	17,715.4
Science	5,073.7	5,115.9	5,017.8	(98.1)	5,017.8	5,017.8	5,017.8	5,017.8
Subtotal, Science	5,079.0	5,121.1	5,017.8	(103.3)	5,017.8	5,017.8	5,017.8	5,017.8
Less Rescissions	(5.3)	(5.3)						
Aeronautics	533.5	572.9	565.7	(7.2)	565.7	565.7	565.7	565.7
Subtotal, Aeronautics	569.9	573.4	565.7		565.7	565.7	565.7	565.7
Less Rescissions	(0.5)	(0.5)						
Space Technology	456.3	577.2	742.6	165.4	742.6	742.6	742.6	742.6
Subtotal, Space Technology	575.0	578.5	742.6		742.6	742.6	742.6	742.6
Less Rescissions	(1.3)	(1.3)						
Exploration	3,821.2	3,790.1	3,915.5	125.4	3,952.0	3,970.7	3,799.0	3,589.3
Subtotal, Exploration	4,394.9	3,793.9	3,915.6		3,952.0	3,970.7	3,799.0	3,589.3
Less Rescissions	(3.7)	(3.7)						
Space Operations	4,184.0	4,249.1	3,882.9	(366.2)	4,014.9	3,996.2	4,167.9	4,377.6
Subtotal, Space Operations	4,194.4	4,259.4	3,882.9		4,014.9	3,996.2	4,167.9	4,377.6
Less Recscissions	(10.4)							
Education	145.4	136.9	94.2	(42.7)	94.2	94.2	94.2	94.2
Subtotal, Education	138.4	139.2	94.2		94.2	94.2	94.2	94.2
Less Rescissions	(2.3)	(2.3)						
Cross Agency Support	2,956.4	3,012.2	2,850.3	(161.9)	2,850.3	2,850.3	2,850.3	2,850.3
Subtotal, Cross Agency Support	2,956.4	3,012.2	2,850.3		2,850.3	2,850.3	2,850.3	2,850.3
Less Rescissions	(0.1	(0.1						
Construction & Environmental Compliance & Restoration	432.9	401.9	609.4	207.5	440.9	440.9	440.9	440.9
Subtotal, Construction & Environmental Compliance & Restoration	432.8	407.4	609.4		440.9	440.9	440.9	440.9
Less Rescissions	-	(0.3						
Office of Inspector General	38.3	38.2	37.0	(1.2	37.0	37.0	37.0	37.0
Subtotal, Inspector General	38.3	38.5	37.0		37.0	37.0	37.0	37.0
Less Rescissions	-	(0.3)						

Fiscal Year 2013 Estimates– NASA is required to submit a spending plan within 45 days of enactment of H.R. 933, the Consolidated and Further Appropriations Act of 2013 (P.L. 113-6),[3] however at the time of this hearing NASA had not submitted their plan and therefore references

[2] President's Budget Request for Fiscal Year 2014 for the National Aeronautics and Space Administration, Congressional Justification. (pg BUD-1).

[3] H.R. 933 (P.L. 113-6), SEC. 537: "The Departments of Commerce and Justice, the National Aeronautics and Space administration, and the National Science Foundation shall submit spending plans, signed by the respective department or agency head, to the Committees on Appropriations of the House of Representatives and the Senate within 45 days after the date of enactment of this Act."

to any final appropriations for fiscal year 2013 are estimates only and based on appropriations from H.J.Res. 117 (P.L. 112-175).[4] All funding levels referenced in this charter do not reflect levels enacted by H.R. 933 (P.L. 113-6).[5] NASA spend plan levels are required by May 10, 2013.

This year's request contains several items of note:

1) While Congress has consistently required NASA spend no less than $1.2 billion[6] on the development of the Orion crew capsule, NASA has requested approximately $200 million less for the third year in a row.
2) NASA requests $821 million this year for the Commercial Crew, which received approximately $500 million in the past two years. The Administration indicated that without the full funding this year, an operational capability will not be achieved by 2017.[7]
3) Although the Administration's request for NASA represents lower amounts throughout the Science, Aeronautics, and Human Exploration and Operations Mission Directorates, they requested an additional $105 million in FY 2014 for the start of a new mission to capture a small near Earth asteroid (NEA) and move it in orbit around the Moon for a future human mission using the Orion and Space Launch System.
4) The Administration's request seeks to transfer several climate sensors from the Joint Polar Satellite System (JPSS) and the Deep Space Climate Observatory (DSCOVR) out of the NOAA budget and assign them to the NASA Earth Science program budget. The budget request also transfers the development of capabilities for the Landsat Data Continuity Mission from the U.S. Geological Survey (USGS) to NASA. It is unclear how NASA will fund these new priorities.
5) The Education Mission Directorate received a significant decrease of approximately 31 percent from the FY13 appropriated amounts as a result of a new Administration initiative to consolidate STEM Education efforts across many agencies.[8]

Asteroid Retrieval Mission

The mission concept proposes the capture and redirect of a small near Earth asteroid (NEA) of 7-10 meters in size to a deep retrograde lunar orbit. Due to the physics involved, NASA cannot simply go to an asteroid, capture it, and tow it into orbit. There are three steps to the mission. First, NASA must identify an appropriate asteroid based on size, composition, and orbit. Next, NASA must develop and launch a robotic probe to the target asteroid and "dock" with it while also stabilizing its rotation. Finally, the probe will "capture" and nudge the object into a trajectory that will allow it to be captured by the moon's gravitational pull.

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[4] President's Budget Request for Fiscal Year 2014 for the National Aeronautics and Space Administration, Congressional Justification, pg BUD-1, footnote 2.
[5] Consolidated and Further Continuing Appropriations Act, 2013
[6] H.R. 3082, Continuing Appropriations and Surface Transportation Extensions Act, 2011; H.R. 2112, Consolidated and Further Continuing Appropriations Act, 2012; HJRes 117, Continuing Appropriations Resolution, 2013; H.R. 933, Consolidated and Further Appropriations Act of 2013.
[7] Oral testimony of NASA Administrator Charles Bolden before the House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies on March 20, 2013.
[8] The White House announced an overall consolidation of STEM education efforts across multiple agencies in the federal government to be coordinated by the Office of Science and Technology Policy. Retrieved at: http://www.whitehouse.gov/sites/default/files/microsites/ostp/2014_R&Dbudget_STEM.pdf

The mission concept is 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.[9] NASA contends that the Keck Study did not take into account existing hardware and development projects already under development by various mission directorates and that the overall cost would be less. NASA intends to complete a more detailed cost estimate this summer.

NASA is proposing three new initiatives totaling $105 million that combine to form the first steps toward the retrieval of an asteroid for human contact by the year 2021:

1. Human Exploration and Operations Mission Directorate – NASA is requesting $40 million in this account to do advanced studies and modeling on how the probe could capture the asteroid and how the Orion crew capsule could rendezvous with it once it is in orbit.
2. Space Technology – In addition to the $4 million NASA already planned for Space Technology Mission Directorate (STMD) work on the development of more advanced Hall Effect thrusters in the Solar Electric Propulsion program, NASA requested a $34 million increase to accelerate this work. They also requested another $7 million for studies and grants that don't necessarily pertain to the mission, but may prove useful in the process.
3. Science Mission Directorate – SMD already manages the Near Earth Object Observation (NEOO) project and requested an additional $20 million for more telescope time for detection of asteroids small enough to meet the mission parameters.

While there is currently no plan, program office, or budget profile available for the mission overall, NASA expects to complete a preliminary mission concept review this summer.

The Administration's proposal comes on the heels of a report issued last December by the National Academy of Sciences about NASA's strategic direction. That report stated that "[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."[10]

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

[10] NASA's Strategic Direction and the Need for a National Consensus http://www.nap.edu/catalog.php?record_id=18248

Human Exploration and Operations Mission Directorate

Budget Authority ($ in millions)	Actual 2012	Estimate 2013	Request 2014	FY13 vs FY14	Notional 2015	2016	2017	2018
Exploration	3,821.2	3,790.1	3,915.5	125.4	3,952.0	3,970.7	3,799.0	3,589.3
Exploration Systems Dev	3,002.0		2,730.0		2,789.8	2,801.5	2,818.3	2,819.5
Commercial Spaceflight	406.0		821.4		821.4	821.4	590.0	371.0
Exploration Research & Dev	303.0		364.2		340.8	347.8	390.7	398.7
Subtotal, Exploration	3,711.0	3,793.9	3,915.6		3,952.0	3,970.7	3,799.0	3,589.2
Less Rescissions	(3.7)	(3.7)						
Space Operations	4,184.0	4,249.1	3,882.9	(366.2)	4,014.9	3,996.2	4,167.9	4,377.6
Space Shuttle	599.3		-		-	-	-	-
International Space Station	2,789.9		3,049.1		3,169.8	3,182.4	3,389.6	3,598.3
Space & Flight Support	805.2		833.8		845.1	813.8	778.3	779.3
Subtotal, Space Operations	4,194.4		3,882.9		4,014.9	3,996.2	4,167.9	4,377.6
Less Rescissions	(10.4)							

The Human Exploration and Operations Mission Directorate is responsible for five broad human space flight areas at NASA; Exploration Systems Development, Commercial Spaceflight, Exploration Research and Development, International Space Station, and Space & Flight Support. NASA is requesting an increase of $125.4 million (3.3 percent) in the Exploration account and a decrease of $366.2 million (8.6 percent) in the Space Operations Account.

Exploration Systems Development

Budget Authority ($ in millions)	Actual 2012	Estimate 2013	Request 2014	FY13 vs FY14	Notional 2015	2016	2017	2018
Exploration	3,821.2	3,790.1	3,915.5	125.4	3,952.0	3,970.7	3,799.0	3,589.3
Exploration Systems Dev	3,002.0		2,730.0		2,789.8	2,801.5	2,818.3	2,819.5
Orion Multipurpose Crew Vehicle	1,200.0		1,026.8		1,024.9	1,027.1	1,027.1	1,028.3
Space Launch System	1,497.5		1,384.9		1,356.5	1,360.2	1,354.4	1,345.4
Exploration Ground Systems	304.5		318.2		408.4	414.2	436.8	445.8
Subtotal, Exploration Systems Dev	3,002.0		2,729.9		2,789.8	2,801.5	2,818.3	2,819.5
Less Rescissions	(10.4)							

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 heavy lift rocket (SLS), the Orion crew capsule (MPCV), and Exploration Ground Systems (EGS). In the NASA Authorization Act of 2010, Congress directed the agency to build these systems to specific requirements.[11] The total request for Exploration Systems Development is $2.73 billion, a 10 percent reduction from what was spent in FY2012 and a reduction of 11 percent from the FY2013 estimate. NASA continues to plan for an initial uncrewed test launch of the SLS and Orion in 2017 and contends they can make progress towards that date with the current request.

Orion Crew Capsule – The Orion is the crew capsule that will carry astronauts beyond LEO. Although Congress has consistently appropriated no less than $1.2 billion for the development of

[11] National Aeronautics and Space Administration Authorization Act of 2010 (P.L. 111-267) at Sec. 302(c)(1).

Orion, NASA requested a reduction in funding for the third year in a row.[12] The request of $1.026 billion is a reduction of approximately 14.5 percent from the FY2013 estimated levels. With the FY14 budget request, NASA announced that the Orion MPCV ascent abort test schedule slipped from 2015 to 2018; however NASA contends that this will not impact the overall schedule for the project and will maximize range safety readiness ahead of the first crewed flight in 2021.

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 metric ton lift capability.[13] This year's request includes a reduction of approximately $60 million for the SLS, 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. This work is on track for that launch date.

Commercial Spaceflight

	Actual	Estimate	Request	FY13 vs	Notional			
Budget Authority ($ in millions)	2012	2013	2014	FY14	2015	2016	2017	2018
Exploration	3,821.2	3,790.1	3,915.5	125.4	3,952.0	3,970.7	3,799.0	3,589.3
Commercial Spaceflight	406.0		821.4		821.4	821.4	590.0	371.0
Commercial Cargo	14.0		-		-	-	-	-
Commercial Crew	392.0		821.4		821.4	821.4	590.0	371.0
Subtotal, Commercial Spaceflight	406.0		821.4		821.4	821.4	590.0	371.0
Less Recscissions								

There are two pieces to the Commercial Spaceflight program at NASA; Commercial Cargo and Commercial Crew. Both initiatives are funded from multiple programs within the Exploration and Space Operations accounts.

Commercial Cargo - The Commercial Spaceflight program at NASA began in 2006 by funding multiple companies to develop systems for transporting cargo to the International Space Station (ISS) with an eye towards eventually having multiple carriers of cargo to compete for the resupply contract. This was accomplished through the Commercial Orbital Transportation Services (COTS) and Cargo Resupply Services (CRS) programs. At this point, only one of the companies involved has successfully delivered and returned cargo from ISS, Space Exploration Technologies Corporation (or SpaceX) in Hawthorne, CA. The other company with a Commercial Resupply Services (CRS) contract, Orbital Sciences Corporation, launched their Antares rocket on Sunday, April 21, 2013 with a mass simulator as a demonstration flight. Like the European Space Agency's ATV or the Japanese Space Agency's HTV, the Cygnus has no down-mass capability. In 2008, NASA signed two CRS contracts for which SpaceX is to receive $1.6 billion for 12 missions and Orbital is to receive $1.9 billion for 8 missions.

[12] President's Budget Request for Fiscal Year 2014 for the National Aeronautics and Space Administration, Congressional Justification . Retrieved at http://www.nasa.gov/pdf/740512main_FY2014%20CJ%20for%20Online.pdf; President's Budget Request for Fiscal Year 2013 for the National Aeronautics and Space Administration, Congressional Justification . Retrieved at http://www.nasa.gov/pdf/659660main_NASA_FY13_Budget_Estimates-508-rev.pdf
President's Budget Request for Fiscal Year 2012 for the National Aeronautics and Space Administration, Congressional Justification . Retrieved at http://www.nasa.gov/pdf/516674main_NASAFY12_Budget_Estimates-Overview-508.pdf

[13] *Ibid. 10*

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 varying sums have been put into these development efforts by each company involved, 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 Commercial Crew program is over 90 percent compared to the private sector investment. NASA intends to invest a total of $1.5 billion for the Commercial Crew Integrated Capability (CCiCap) and certification products contracts (CPC). Contracts for services would be in addition to these investments.

For the last three years in FY11, FY2012, and FY2013 Congress appropriated $307.4 million, $392.0, and $525 million respectively for the program. This year NASA requested $821.4 million which represents an increase of $424.9 million (109.5 percent) over FY2012 and an increase of approximately $296.4 (56.4 percent) above the FY2013 estimate. In a hearing before the Commerce, Justice, Science and Related Agencies Appropriations Subcommittee, Administrator Bolden warned, "If we aren't able to get up to $800 million level, then I will have to come back and officially notify the Congress that we cannot make 2017 for availability of commercial crew."[14] It is unclear if NASA would be able to make that date if they adopted a different development strategy.

Exploration Research and Development

	Actual	Estimate	Request	FY13 vs	Notional			
Budget Authority ($ in millions)	2012	2013	2014	FY14	2015	2016	2017	2018
Exploration	3,821.2	3,790.1	3,915.5	125.4	3,952.0	3,970.7	3,799.0	3,589.3
Exploration Research and Dev	299.7		364.2		370.8	347.8	390.7	398.7
Human Research Program	157.7		165.1		164.6	169.5	175.4	180.0
Advanced Exploration Systems	145.3		199.0		176.2	178.3	215.3	218.7
Subtotal, Exploration Research and Dev	303.0		364.1		340.8	347.8	390.7	398.7
Less Recscissions								

The president's FY2014 request for Exploration Research and Development is $364.2 million, an increase of $64.7 million (21.6 percent) above FY2012 and $30.5 million (10 percent) above the FY2013 request.

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 - The most difficult questions to answer about extended human presence in space are about the effects of microgravity, radiation, and other related environmental factors on the human body. Additionally, this program address questions about 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, and robotic precursor

[14] *Ibid.6*

missions that gather critical knowledge about potential destinations in advance of crewed missions.

Space Operations

Budget Authority ($ in millions)	Actual 2012	Estimate 2013	Request 2014	FY13 vs FY14	Notional 2015	2016	2017	2018
Space Operations	**4,184.0**	**4,249.1**	**3,882.9**	**(366.2)**	**4,014.9**	**3,996.2**	**4,167.9**	**4,377.6**
Space Shuttle Program	596.2		-		-	-	-	-
International Space Station	2,789.9		3,049.1		3,169.8	3,182.4	3,389.6	3,598.3
Space & Flight Support	797.9		833.8		845.1	813.8	778.3	779.3
Subtotal, Space Operations	**3,587.8**		**3,882.9**		**4,014.9**	**3,996.2**	**4,167.9**	**4,377.6**
Less Recscissions								

The Space Operations Account funds activities for the International Space Station as well as 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 FY2014 is $3.882 billion which represents a decrease of $366.1 million (8.6 percent).

International Space Station – The ISS is a permanently crewed microgravity laboratory and technology test bed for exploration and international cooperation. The ISS also includes a National Laboratory for non-NASA and potential non-governmental users. The NASA Authorization Act of 2010 required NASA to compete a contract for management of the National Laboratory and the Center for the Advancement of Science in Space (CASIS)[15] was selected for this purpose. As of October 2012, more than 1,400 investigators from 63 countries around the world have performed approximately 1,500 research investigations utilizing ISS.

The ISS Program contains three major projects: Systems Operations and Maintenance (O&M), Research, and Crew and Cargo Transportation.[16] As noted earlier, funding to procure commercial crew or cargo transportation is in the ISS Crew and Cargo Transportation program within the ISS budget. The president's FY2014 budget request for the International Space Station is $3.049 billion, an increase of $260 million (9.3 percent) over FY2012 and an increase of $42 million (1.3 percent) over the FY2013 request.

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

[15] *Ibid.* 10, at Title 5, Sec. 504

[16] While the development of commercial cargo was funded initially from the Exploration account, the services provided under the CRS contract are funded from Space Operations. The same will be true of commercial crew development. When NASA chooses contractors to take crew to ISS, that contract will be funded from Space Operations.

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.

NASA Science Mission Directorate

Budget Authority ($ in millions)	Actual 2012	Estimate 2013	Request 2014	FY13 vs FY14	Notional 2015	2016	2017	2018
Science	5,073.7	5,115.9	5,017.8	(98.1)	5,017.8	5,017.8	5,017.8	5,017.8
Earth Science	1,765.7		1,846.1		1,854.6	1,848.9	1,836.9	1,838.1
Planetary Science	1,501.4		1,217.5		1,214.8	1,225.3	1,254.5	1,253.0
Astrophysics	648.4		642.3		670.0	686.8	692.7	727.1
James Webb Space Telescope	518.6		658.2		645.4	620.0	569.4	534.9
Heliophysics	644.9		653.7		633.1	636.8	664.3	664.6
Subtotal, Science	5,079.0	5,121.1	5,017.8	(103.3)	5,017.9	5,017.8	5,017.8	5,017.7
Less Rescissions	(5.3)	(5.3)						

The Science Mission Directorate (SMD) conducts scientific exploration enabled by the observatories and probes that view Earth from space, observe and visit other bodies in the solar system, and gaze out into the galaxy and beyond. The directorate has four divisions; Earth Science, Planetary Science, Astrophysics and Heliophysics. NASA is requesting $5.017 billion for SMD this year which is a reduction of approximately $98.1 million (two percent) below the FY2013 estimate.

Transfer of instruments from NOAA –The Administration requested authority to relocate three JPSS climate sensors from NOAA to NASA: Clouds and Earth Radiant Energy System (CERES), the Ozone Mapping and Profiler Suite-Limb (OMPS-Limb) and the Total Irradiance Sensor (TSIS). The Administration's request also requires NASA to develop two climate sensors for the Deep Space Climate Observatory (DSCOVR), the Earth Polychromatic Imaging Camera (EPIC) and the NIST Advanced Radiometer (NISTAR) for NOAA. This is in addition to NASA's new responsibility to develop a national sustained Land Imaging Satellite System, which was transferred from USGS. There is a one-time budget plus-up requested of $40 million for the development of all of these sensors. At this time it is unclear how NASA plans to cover the cost of these new climate instruments after FY2014.

Earth Science – The Earth Science division at NASA advances the state of Earth system science by advancing our understanding of environmental change through data acquisition, scientific and application research and analysis, and predictive modeling. The Earth Science division currently operates 17 Earth observing satellite missions, including 15 that are in extended operations beyond their designed expected lifecycle. NASA uses these satellites to monitor sea levels and salinity, groundwater depletion rates, sea ice erosion, carbon dioxide levels, and many other phenomena.

Planetary Science – The Planetary Science division of SMD 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 Near Earth Object Observations program which thus far has surveyed about 95 percent of the known population of 1-kilometer and larger objects and has increased efforts for finding and characterizing smaller asteroids. Current and

past projects from Planetary Science include missions to: Jupiter (JUNO), Mars (Mars Science Laboratory -- MSL) and the moon (GRAIL). The Planetary Science program was targeted for deep reductions over the last four years as NASA prioritized missions in Earth Science and underestimated costs to develop the James Webb Space Telescope.

In February of 2012, NASA created the Mars Program Planning Group (MPPG) to develop a revised and more affordable Mars Exploration program. In September of 2012, MPPG released their final recommendation to NASA.[17] Consistent with the Decadal Survey, MPPG endorsed a Mars Sample Return Mission as well as additional rovers and orbiters as "building blocks" for eventual human exploration.[18] The next mission to Mars will be the Mars Atmosphere & Volatile Evolution (MAVEN) orbiter scheduled for launch in November 2013.

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 currently operates 11 spacecraft, including the Hubble Space Telescope and Kepler, the planet hunter, which recently announced the discovery of even more Earth-like planets. The most recent Decadal Survey recommended increasing funding to competitive research programs within Astrophysics and this year's request is consistent with that recommendation. Also in response to recommendations from the survey, NASA introduced a new competitive program called the Theory and Computational Astrophysics Networks which is a joint program with the National Science Foundation. The program will offer three-year awards for networked teams distributed across multiple institutions to address key challenges in theoretical astrophysics.

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 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 L_2 point approximately 930,000 miles from the Earth and stands three stories high, spanning the size of a tennis court.

Beginning in FY2012, 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 FY2013 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. The division operates 18 missions including Voyager, which launched in 1977, the Solar and Heliospheric Observatory (SOHO) and the Solar Terrestrial Relations Observatory (STEREO). NASA plans to support a flight

[17] Mars Program Planning Group Final Report Summary, delivered on September 25, 2012. Retrieved at http://www.nasa.gov/pdf/691580main_MPPG-Integrated-v13i-Summary percent20Report-9-25-12.pdf
[18] *Ibid.*

program of up to 24 sounding rocket flights in FY2014 for heliophysics instruments as well as awarding over 85 new investigations.

Aeronautics Research Mission Directorate

Budget Authority ($ in millions	Actual 2012	Estimate 2013	Request 2014	FY13 vs FY14	Notional 2015	2016	2017	2018
Aeronautics	533.5	572.9	565.7	(7.2)	565.7	565.7	565.7	565.7
Aviation Safety	80.1		80.0		80.3	81.5	82.4	82.5
Airspace Systems	92.7		91.5		91.5	91.9	92.4	92.4
Fundamental Aeronautics	1,866.3		168.0		166.9	163.4	160.1	159.7
Aeronautics Test	79.4		77.0		77.5	78.6	79.6	79.8
Integrated Systems Research	104.2		126.5		126.8	127.4	128.2	128.4
Aeronautics Strategy & Management	27.2		22.7		22.7	22.8	22.9	22.9
Subtotal, Aeronautics	569.9	573.4	565.7	(7.7)	565.7	565.7	565.7	565.7
Less Rescissions	(0.5)	(0.5)						

NASA's aeronautics programs are conducted by the Aeronautics Research Mission Directorate (ARMD) and focus on long-term investments in fundamental aeronautics research to improve aviation safety, efficiency and air traffic management. The ARMD program areas include; Aviation Safety, Airspace Systems, Fundamental Aeronautics, Aeronautics Test Program, Integrated Systems Research, and Aeronautics Strategy and Management. The FY2014 request for ARMD this year is $565.7 million, a decrease of $7.2 million (1.2 percent) from the FY2013 estimate.

Notable changes in the ARMD budget for FY14 include a new $25 million initiative to reduce the timeline for development and certification of innovative composite materials and structures named the Advanced Composites Project. The FY14 budget request also reinvigorates rotorcraft research after a several year hiatus.

Aviation Safety – Aviation Safety develops technologies to improve aviation system-wide safety, advances the state-of-the-art of aircraft systems and flight crew operations, develops data mining algorithms to search through large data sets to discover unknown safety threats, and addresses the inherent presence of atmospheric risks to aviation.

Airspace Systems – Airspace Systems develops and explores fundamental concepts and technologies to increase throughput of the National Airspace System and achieve high resource efficiency, and transitions key technologies from the laboratory to the field.

Fundamental Aeronautics – Fundamental Aeronautics conducts fundamental research to improve aircraft performance and minimize environmental impacts, research for low boom supersonic aircraft, and improving the effectiveness of rotary wing vehicles.

Aeronautics Test Program –Aeronautics Test Program manages NASA's aeronautics test capabilities in partnership with the Department of Defense. The program also designs, constructs, and validates testing environments.

Integrated Systems Research Program (ISRP) – Integrated Systems Research Program conducts integrated system-level research to accelerate transitioning into major aircraft and operations

systems. The Program also develops an adaptable, scalable, and schedulable test environment for validating concepts and technologies for unmanned aircraft systems to safely operate in the National Airspace System. ISRP is also the program which will administer the Advanced Composites project.

Aeronautics Strategy and Management – Aeronautics Strategy and Management identifies new innovative aviation concepts through "seedling funds" that provide research and analysis of early stage concepts. Also funds ARMD's institutional expenses, as well as NASA's portion of the Joint Planning and Development Office (a program within NextGen) costs.

Space Technology

Budget Authority ($ in millions)	Actual 2012	Estimate 2013	Request 2014	FY13 vs FY14	Notional 2015	2016	2017	2018
Space Technology	456.3	577.2	742.6	165.4	742.6	742.6	742.6	742.6
Partnerships Dev & Strategic Integration	29.5		34.1		34.3	34.4	34.5	34.6
SBIR & STTR	171.6		186.4		192.0	200.4	211.6	211.6
Crosscutting Space Tech Dev.	183.9		277.6		256.2	213.2	241.0	244.3
Exploration Tech Dev.	190.0		244.5		260.1	294.6	255.5	252.0
Subtotal, Space Technology	575.0	578.5	742.6	164.1	742.6	742.6	742.6	742.6
Less Rescissions	(1.3)	(1.3)						

NASA announced on February 21, 2013 that it was creating a new mission directorate and appointed a new associate administrator for a Space Technology Mission Directorate (STMD). Although Congress has never explicitly authorized it, the FY2012 appropriation NASA received a specific account called "Space Technology" with an appropriation of $573.7 million. Additionally, Congress appropriated $642 million in the FY2013 continuing resolution.[19] NASA has requested $742.6 million this year for Space Technology which is an increase of $165.4 million (29 percent).

The FY14 budget request accelerates the development of a high-powered Solar Electric Propulsion (SEP) system for the robotic asteroid retrieval mission. NASA plans to use the proposed STMD to focus on technology development and demonstration which could enable a new class of NASA missions beyond low Earth. Additionally, NASA believes STMD can better leverage investments in technologies and also better transfer technology to the private sector. In February of this year, NASA released a "Strategic Space Technology Investment Plan" which details the broad goals of STMD going forward.

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 nine major projects identified by NASA as critical within their various program offices, they are referred to as "the big nine", they include: Laser communications, Cryogenic

[19] H.R. 933, (P.L. 113-6), Consolidated and Further Appropriations Act of 2013 at Title III.

Propellant Storage & Transfer, Deep Space Atomic Clock, Large-Scale Solar Sail, Low Density Supersonic Decelerators, Green Propellants, Human Exploration Telerobotics and Human-Robotics Systems, Solar electric Propulsion, and Composite Cryotank.

Education

Budget Authority ($ in millions)	Actual 2012	Estimate 2013	Request 2014	FY13 vs FY14	Notional 2015	2016	2017	2018
Education	136.1	136.9	94.2	(42.7)	94.2	94.2	94.2	94.2
Aerospace Rsch & Career Dev	58.4		33.0		33.0	33.0	33.0	33.0
STEM Education & Accountability	80.0		61.2		61.2	61.2	61.2	61.2
Subtotal, Space Operations	138.4		94.2		94.2	94.2	94.2	94.2
Less Recscissions	(2.3)	(2.3)						

The President's FY 2014 request for NASA's Education program is $94.2 million, a $42.7 million (31.3 percent) decrease from the FY2013 estimate. This year the President's request announced a major initiative to consolidate and reorganize STEM education initiatives across the federal government. Additional details outlining these significant changes are expected later this summer. While most of the specialized outreach and education initiatives that are unique to NASA will remain in the agency, the STEM education efforts will be fundamentally restructured into a consolidated education program within NASA's Office of Education, and will coordinate closely with the Department of Education, the National Science Foundation, and the Smithsonian Institution in leading and executing the Administration's STEM Education efforts.

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 second program in ARCD is EPSCoR, which is a competiive grant project that establishes partnerships between government, higher education, and industry to promote 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 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. NASA has consolidated the education functions, assets, and efforts of the Aeronautics Research Mission Directorate, Science Mission Directorate and Human Exploration and Operations Mission Directorate into a single coordinated STEM Education and Accountability Project (SEAP). According to the Office of Science and Technology Policy, this new structure will enhance coordination with other agencies and will

make its people, resources, facilities, and discoveries available to key stakeholders and strategic partners.

Chairman PALAZZO. Well, good afternoon. Welcome to today's hearing titled An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014.

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

Good afternoon. I would like to welcome everyone to our hearing today, and I especially want to thank our witness, NASA Administrator Charlie Bolden, for joining us. I know many people put in a lot of effort preparing for these hearings, and we appreciate you taking time from your busy schedule to appear before the Subcommittee.

The purpose of today's hearing is to review the Administration's Fiscal Year 2014 budget request for the National Aeronautics and Space Administration and to examine its priorities and challenges.

Before we review the details of the NASA request, I feel it is necessary to express my disappointment that the Administration has been unable to fulfill its responsibilities for a timely budget as required under the Budget and Accounting Act. In the future, I hope the Administration will be on time.

This year NASA is requesting $17.7 billion, a decrease of $55 million from Fiscal Year 2012 and $733 million less than Fiscal Year 2011. In a time of budgetary restraints such as the one our Nation is facing, we must ensure that every agency is doing its part, and I believe the top line request for NASA is fair in this regard.

There are several areas of the request that I believe require serious deliberation and thoughtful debate. Within the Human Operations and Exploration Mission Directorate, I am most concerned with the requests for the Commercial Crew Program, the Space Launch System and the Orion crew capsule. Certainly the successful launches of both SpaceX and Orbital Sciences are significant milestones, and they should be applauded for those achievements. However, I continue to be concerned about the strategy NASA is employing to fund crew transportation systems.

We must recognize the times in which we are operating. If funding multiple companies to develop these systems is no longer feasible, we must reevaluate our strategy. Our first priority must be getting American astronauts launching on American rockets from American soil as soon as safely possible. I am skeptical about continuing to develop a market as broad and as deep as NASA suggests because I think it could delay that goal. This is a conversation I anticipate revisiting as the Committee prepares for the NASA reauthorization later this year.

Additionally, I am concerned about the requests for the Space Launch System and the Orion crew capsule. While Congress continues to insist that these two programs be priorities, NASA has once again offered a budget that does not demonstrate the sustained commitment to their development. I remain committed to ensuring our Nation has a robust exploration program, and I am curious what milestones or important testing NASA believes can be pushed out in the schedule to accommodate the lower request.

I am also troubled by NASA's requested reductions in the Science, Aeronautics, and Human Exploration and Operations Mission Directorates, while asking for $105 million for an Asteroid Retrieval Mission that was announced seemingly out of the blue. This request was not accompanied by a budget profile, technical plan or long-term strategy. Yet NASA has asked Congress to commit to funding the first steps. I look forward to hearing more about this mission and how NASA intends to cover the $2.6 billion that the Keck Institute for Space Studies estimated it would cost.

In the Science Mission Directorate, the Administration has requested authority to transfer several climate sensors from the troubled Joint Polar Satellite System and the Deep Space Climate Observatory out of the NOAA budget and assign them to the Earth Science program budget. The budget request also transfers Landsat Data Continuity Mission follow-on activities from the U.S. Geological Survey to NASA and the development infrastructure for Radioisotope Power Systems from the Department of Energy to NASA. So I am worried that NASA is footing the bill for other agency requirements, all while being asked to take an overall budget cut.

Finally, I am concerned by the growth of the Space Technology program. The request for the Space Technology program this year is a 62 percent increase over the appropriation it received in Fiscal Year 2012. This is a significant amount of growth in only two years. Although NASA has announced that it will organize Space Technology as a mission directorate, it has not requested authority to do so in the upcoming authorization bill and it is not entirely clear how the projects in Space Technology differ from those in the other mission directorates.

Mr. Administrator, like you, I am committed to ensuring that our Nation has a robust space program that will continue to lead the world for generations. I am concerned, however, that NASA has neglected Congressional funding priorities and been distracted by new and questionable missions that detract from our ultimate deep space exploration goals. These distractions also take up precious lines in the budget at a time when NASA can least afford it.

[The prepared statement of Mr. Palazzo follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON SPACE CHAIRMAN STEVEN PALAZZO

Good afternoon. I would like to welcome everyone to our hearing today and I especially want to thank our witness, NASA Administrator Charlie Bolden, for joining us. I know many people put in a lot of effort preparing for these hearings, and we appreciate you taking time from your busy schedule to appear before the Subcommittee.

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Before we review the details of the NASA request, I feel it is necessary to express my disappointment that the Administration has been unable to fulfill its responsibilities for a timely budget as required under the Budget and Accounting Act. In the future, I hope the Administration will be on time.This year NASA is requesting $17.7 billion, a decrease of $55 million from fiscal year 2012 and $733 million less than fiscal year 2011. In a time of budgetary restraints such as the one our nation is facing, we must ensure that every agency is doing its part, and I believe the topline request for NASA is fair in this regard.

There are several areas of the request that I believe require serious deliberation and thoughtful debate. Within the Human Operations and Exploration Mission Directorate I am most concerned with the requests for the Commercial Crew Program,

the Space Launch System and the Orion crew capsule. Certainly the successful launches of both SpaceX and Orbital Sciences are significant milestones and they should be applauded for those achievements, however, I continue to be concerned about the strategy NASA is employing to fund crew transportation systems.

We must recognize the times in which we are operating, if funding multiple companies to develop these systems is no longer feasible, we must reevaluate our strategy. Our first priority must be getting American astronauts launching on American rockets from American soil as soon as is safely possible. I am skeptical about continuing to develop a market as broad and as deep as NASA suggests because I think it could delay that goal. This is a conversation I anticipate revisiting as the Committee prepares for the NASA reauthorization later this year.

Additionally, I am concerned about the requests for the Space Launch System and the Orion crew capsule. While Congress continues to insist that these two programs be priorities, NASA has once again offered a budget that does not demonstrate a sustained commitment to their development. I remain committed to ensuring our nation has a robust exploration program and I am curious what milestones or important testing NASA believes can be pushed out in the schedule to accommodate the lower request.

I am also troubled by NASA's requested reductions in the Science, Aeronautics, and Human Exploration and Operations Mission Directorates, while asking for $105 million for an asteroid retrieval mission that was announced seemingly out of the blue. This request was not accompanied by a budget profile, technical plan, or long-term strategy. Yet NASA has asked Congress to commit to funding the first steps. I look forward to hearing more about this mission and how NASA intends to cover the $2.6 billion that the Keck Institute for Space Studies estimated it would cost.

In the Science Mission Directorate, the Administration has requested authority to transfer several climate sensors from the troubled Joint Polar Satellite System (JPSS) and the Deep Space Climate Observatory (DSCOVR) out of the NOAA budget and assign them to the Earth Science program budget. The budget request also transfers Landsat Data Continuity Mission follow-on activities from the U.S. Geological Survey (USGS) to NASA, and the development infrastructure for Radioisotope Power Systems from the Department of Energy (DOE) to NASA. I am worried that NASA is footing the bill for other agency requirements; all while being asked to take an overall budget cut.

Finally, I am concerned by the growth of the Space Technology program. The request for the Space Technology program this year is a 62% increase over the appropriation it received in fiscal year 2012. This is a significant amount of growth in only two years. Although NASA has announced that it will organize Space Technology as a mission directorate, it has not requested authority to do so in the upcoming authorization bill and it is not entirely clear how the projects in Space Technology differ from those in the other mission directorates.

Mr. Administrator, like you, I am committed to ensuring that our nation has a robust space program that will continue to lead the world for generations. I am concerned however that NASA has neglected Congressional funding priorities and been distracted by new and questionable missions that detract from our ultimate deep space exploration goals. These distractions also take up precious lines in the budget at a time when NASA can least afford it.

Chairman PALAZZO. I now recognize the Ranking Member, the gentlelady from Maryland, Ms. Edwards, for an opening statement.

Ms. EDWARDS. Thank you, Mr. Chairman, and good afternoon and welcome to Administrator Bolden. Before I begin, I want to offer my congratulations to NASA and to Orbital on the test flight of the Antares launcher on Sunday. The successful test flight speaks well of the teamwork among Orbital, NASA and the Wallops Flight Facility and the FAA including the Mid-Atlantic Regional Spaceport in the Virginia Commercial Space Flight Authority. So congratulations.

Now today we are meeting to review the $17.7 billion request for NASA's Fiscal Year 2014 budget, and I know, General Bolden, that it has not been easy getting to this point. With sequestration and the late resolution of the fiscal 2013 budget, we in Congress have not provided you with the optimal conditions under which to plan

and implement NASA's inspiring portfolio of missions, but here we are.

Now I have said before and I will say it again that our investments in research and development, including space, are investments in innovation, jobs and future economic growth. If we skimp on the input side of the equation, we can't expect positive changes in our Nation's capacity for innovation and growth. That is why we need to take a careful look at how the resources requested match the program content included in the Fiscal Year 2014 budget request.

At the Full Committee hearing just last week on the Fiscal Year 2014 budget request for science agencies, the President's science advisor, Dr. Holdren, testified, and I quote, "NASA has long had the problem of 20 pounds of mission in a 10-pound budget and they continue to." I share that concern. This proposal includes requests for NASA's key priorities, the James Webb Space Telescope, the International Space Station and the Space Launch System and Orion Crew Vehicle, along with its science and aeronautics programs and its infrastructure support.

I worry that for all the work that NASA is tasked with doing to move forward toward fulfilling the 2010 NASA Reauthorization Act that the agency is also cherry-picking aspects of that strategic plan that it finds favorable while undercutting other priorities in the law. For example, the 2014 budget request includes $105 million as a down payment to fund initial concept work on a mission that would demonstrate solar electric propulsion technology that is needed to capture a small asteroid, move it into trans-lunar region and then potentially use that asteroid as a target destination for the first crewed flight of the SLS and Orion system. In addition, the request includes $820 million a year over the next several years to fund the development of Commercial Crew capability for transporting astronauts to and from the ISS, a significant increase from the $400 million and $500 million range that Congress has been willing to authorize and appropriate for those activities in the last three fiscal years. My fear is that I have already gotten to the 20 pounds of program content that Dr. Holdren was talking about in NASA's $17.7 billion request. And that doesn't include the unfunded new responsibilities for developing climate sensors that NASA's Earth Science program has inherited from NOAA, the $50 million increase required for full reimbursement now to the Department of Energy for resuming the domestic production of material that is needed to power deep space missions, or the 29 percent increase over Fiscal Year 2012 actual spending levels that is being sought for NASA's Space Technology program.

To NASA's credit, the agency has been making progress in managing schedule and cost on its activities. The Government Accountability Office just recently issued a report that stated that NASA had success in the last two years in launching missions on cost or on schedule. I commend the agency and the contractor workforce on this progress, and yet the GAO also says that sustaining the changes that have led to these successes will be challenging within a period of flat or decreasing budgets and with the ongoing work on several large-scale and complex projects. Should any of the JWST, ISS or SLS/Orion programs experience a hiccup, the finan-

cial impact could have, and this is quoting GAO, "cascading effects on the rest of the portfolio." Indeed, GAO's word of caution gives me pause since I don't see a lot of flexibility within the 2014 request for dealing with that situation. I hope today's discussion can clarify the rationale for the proposed asteroid and capture retrieval initiative proposed in the 2014 budget and particularly how it contributes to detecting and characterizing 90 percent of near-Earth asteroids 140 meters in diameter or less—we have heard testimony in this Committee about that—as set in policy and successive authorization acts.

In these tight budgetary times, we need to be sure the proposed approach will be the most efficient means of achieving those objectives. So I look forward, Administrator Bolden, to what I hope will be a beginning of an active dialogue on both the policy and resources required to support NASA and in effectively implementing its challenging and inspiring portfolio. And I thank you, Mr. Chairman, and yield, well, not the balance of my time, but I do yield.

[The prepared statement of Ms. Edwards follows:]

PREPARED STATEMENT OF RANKING MINORITY MEMBER DONNA EDWARDS

Good afternoon and welcome, General Bolden. Before I start, I'd like to offer my congratulations to NASA and Orbital on the test flight of the Antares launcher on Sunday. The successful test flight speaks well of the teamwork among Orbital, NASA, the Wallops Flight Facility, the Federal Aviation Administration (FAA), the Mid-Atlantic Regional Spaceport, and the Virginia Commercial Space Flight Authority.

Today, we're meeting to review the $17.7 billion request for NASA's Fiscal Year 2014 budget.

I know, General Bolden, that it has not been easy getting to this point. With sequestration and the late resolution of the Fiscal Year 2013 budget, we in Congress have not provided you with the optimal conditions under which to plan and implement NASA's inspiring portfolio of missions.

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At the Full Committee hearing last week on the Fiscal Year 2014 budget request for Science Agencies, the President's Science Adviser, Dr. Holdren, testified that ″NASA has long had the problem of 20 lbs. of missions in a 10 lb. budget, and they continue to.″ I share that concern.This proposal includes requests for NASA's key priorities—the James Webb Space Telescope, the International Space Station (ISS), and the Space Launch System (SLS) and Orion crew vehicle—along with its Science and Aeronautics programs, and its infrastructure support.

I worry that for all the work NASA is doing to move towards fulfilling the 2010 NASA Authorization Act, that the Agency is also cherry picking aspects of that strategic plan that it finds favorable while undercutting other priority areas in the law.

For instance, the FY 2014 budget request includes a $105 million down payment to fund initial concept work on a mission that would demonstrate solar-electric propulsion technology that is needed to capture a small asteroid, move it into a translunar region, and then potentially use that asteroid as a target destination for the first crewed flight of the SLS and Orion system.

In addition, the request includes $820 million a year over the next several years to fund the development of Commercial Crew capability for transporting astronauts to and from the ISS, a significant increase from the $400 and $500 million range that Congress has been willing to authorize and appropriate for those activities in the last three fiscal years.

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And that doesn't include the unfunded new responsibilities for developing climate sensors that NASA's Earth Science program has inherited from NOAA, the $50 mil-

lion increase required for full reimbursement to the Department of Energy for resuming the domestic production of material that is needed to power deep space missions, or the 29 percent increase over FY 2012 actual spending levels being sought for NASA's Space Technology Program.

To NASA's credit, the agency has been making progress in managing schedule and cost on its activities. The Government Accountability Office (GAO) just recently issued a report that stated: ″NASA has had success in the last two years in launching missions on cost or on schedule.″ I commend the NASA and contractor workforce on this progress.

Yet, the GAO also says that sustaining the changes that have led to these successes will be challenging within a period of flat or decreasing budgets and with the ongoing work on several large-scale and complex projects.

Should any of the JWST, ISS, or the SLS/Orion programs experience a hiccup, the financial impact could have "cascading effects on the rest of the portfolio," as GAO puts it.

GAO's words of caution give me pause since I don't see a lot of flexibility within the FY2014 request for dealing with that situation.

I hope that today's discussion can clarify the rationale for the proposed asteroid and capture retrieval initiative proposed in the FY 2014 budget, particularly how it contributes to detecting and characterizing 90 percent of near-Earth asteroids 140 meters in diameter or less, and how it advances our capability of sending humans to destinations such as Mars, as set in policy in successive Authorization Acts. In these tight budgetary times, we need to be sure the proposed approach will be the most efficient means of achieving those objectives.

So, I look forward, Administrator Bolden, to what I hope will be the beginning of an active dialogue on both the policy and the resources required to support NASA in effectively implementing its challenging and inspiring portfolio.

Chairman PALAZZO. Thank you, Ms. Edwards. I now recognize the Chairman of the Full Committee for a statement, Mr. Smith.

Chairman SMITH. Thank you, Mr. Chairman. America is a Nation of explorers, and space is the next frontier. Just last week, NASA announced the discovery of new worlds beyond our solar system that resemble our own planet.

We in Congress need to be diligent in our review of the Administration's proposed budget for NASA to ensure that this agency remains focused on its primary mission, space exploration.

In April 2010, almost three years ago, President Obama addressed the NASA workforce at the Kennedy Space Center. He stated that the next mission for American astronauts beyond the International Space Station was an asteroid and canceled NASA's many years of work to return to the surface of the Moon.

Last December, a National Academy of Sciences review of NASA's strategic direction made the following observation. "The 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."

Not having found a suitable asteroid for NASA astronauts, the President's budget now proposes a robotic Asteroid Retrieval Mission to bring one closer to the Moon. NASA's budget does not identify where the funding for such an Asteroid Retrieval Mission will come from, but it is likely to detract from NASA's human spaceflight projects, the International Space Station, Orion Crew Vehicle, and Space Launch System.

Further, the President's budget requests over $1.8 billion for NASA's Earth Science programs.

How does this high level of spending affect other NASA priorities, especially planetary exploration?

Here are the priorities for NASA's exploration missions that have been consistent in Congressional authorizations for the past eight years. We need to make the International Space Station both an international and scientific success that will enable further exploration beyond Earth orbit. We need to build new systems to once again launch American astronauts on American rockets as soon as possible. Today, the United States pays Russia $63 million to take each of our astronauts to the station.

While we support certain investments by NASA to fund private sector cargo and crew initiatives to support the station, Congress has been clear over the years that the Orion Crew Vehicle serve as a backup option.

And finally, after receiving testimony from many engineers and astronauts, Congress has been insistent that in order to venture beyond low-Earth orbit, a heavy-lift launch vehicle, NASA's Space Launch System, needs to be developed.

The goal of NASA's human spaceflight program is to go to Mars and beyond on a path that includes returning to the Moon or asteroids as necessary. This stepping-stone approach for our exploration out of low-Earth orbit is clear and unambiguous.

While Federal budgets will continue to be uncertain, congressional support for NASA's exploration mission is clear and unwavering.

Thank you Mr. Chairman, I will yield back.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF CHAIRMAN LAMAR SMITH

America is a nation of explorers, and space is the next frontier. Just last week, NASA announced the discovery of new worlds beyond our solar system that resemble our own planet.

We in Congress need to be diligent in our review of the Administration's proposed budget for NASA to ensure that this agency remains focused on its primary mission-space exploration.

In April 2010-almost three years ago-President Obama addressed the NASA workforce at the Kennedy Space Center. He stated that the next mission for American astronauts beyond the International Space Station was an asteroid, and canceled NASA's many years of work to return to the surface of the Moon.

Last December, a National Academy of Sciences review of NASA's strategic direction made the following observation:

> "The 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."

Not having found a suitable asteroid for NASA astronauts, the President's budget now proposes a robotic asteroid retrieval mission to bring one closer to the Moon. NASA's budget does not identify where the funding for such an asteroid retrieval mission will come from. But it is likely to detract from NASA's human spaceflight projects, the International Space Station, Orion Crew Vehicle and Space Launch System.

Further, the President's budget requests over $1.8 billion for NASA's Earth Science programs.

How does this high level of spending affect other NASA priorities, especially planetary exploration?

Here are the priorities for NASA's exploration missions that have been consistent in Congressional authorizations for the past eight years:

- We need to make the International Space Station both an international and scientific success that will enable further exploration beyond Earth orbit.
- We need to build new systems to once again launch American astronauts on American rockets as soon as possible. Today, the U.S. pays Russia $63 million to take each of our astronauts to the Station.
- While we support certain investments by NASA to fund private sector cargo and crew initiatives to support the Station, Congress has been clear over the years that the Orion Crew Vehicle serve as a backup option.
- And finally, after receiving testimony from many engineers and astronauts, Congress has been insistent that in order to venture beyond Low-Earth orbit, a heavy-lift launch vehicle-NASA's Space Launch System-needs to be developed.

By contrast, I am disheartened by the Administration's ever-changing goals and their lack of justifications and details.

The goal of NASA's human spaceflight program is to go to Mars and beyond on a path that includes returning to the moon or asteroids as necessary. This stepping-stone approach for our exploration out of low-earth orbit is clear and unambiguous.

While federal budgets will continue to be uncertain, Congressional support for NASA's exploration mission is clear and unwavering.

Thank you Mr. Chairman, I yield back the remainder of my time.

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

[The prepared statement of Ms. Johnson appears in appendix II]

Chairman PALAZZO. At this time I would like to introduce today's witness, The Honorable Charles F. Bolden, Jr., the Administrator of the National Aeronautics and Space Administration. I now recognize Administrator Bolden to present his testimony.

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

General BOLDEN. Thank you very much, Mr. Chairman and Members of the Committee. Let me thank you for the opportunity to appear today to discuss NASA's Fiscal Year 2014 budget request.

Let me start by thanking the Full Committee as well as this Subcommittee for your continued bipartisan support of NASA and the world's second-to-none civil space program. That support is also reflected among the American people and the White House as evidence by the President's $17.7 billion funding request for NASA. The budget reflects today's fiscal realities, and it aligns NASA's full spectrum of activities to meet the President's challenge to send humans to an asteroid by 2025 and to Mars in the 2030s.

As part of the agency's overall asteroid strategy, NASA is planning a first-ever mission to identify, capture, and redirect an asteroid into orbit around the Moon. This mission represents an unprecedented technological challenge raising the bar for human exploration and discovery while helping protect our home planet and keep bringing us closer to a human mission to Mars in the 2030s.

This budget also supports NASA's partnerships with American industry partners who are developing new ways to reach space. These partnerships are creating jobs and enabling NASA to focus on new technologies that benefit all of our missions. An industry partner, Space-X, has begun resupplying the International Space Station with cargo launched from the United States, and Sunday's

successful test launch of Orbital Science's Antares marks another significant milestone in NASA's plan to rely on American companies to launch supplies and astronauts to the International Space Station.

Orbital is now poised for its first demonstration launch and mission to the ISS later this year. The Administration is committed to launching American astronauts from U.S. soil within the next four years, and this budget provides the necessary resources to achieve this goal. This budget fully funds the International Space Station that remains the springboard to our next great leap in exploration. It also continues investments that are developing the SLS rocket and Orion Crew Vehicle that will take astronauts to deep space and it supports driving the development of space technologies such as solar electric propulsion that will power tomorrow's missions and help improve life here on Earth.

This budget continues to build on our Nation's record of breathtaking scientific discoveries and achievements in space with science missions that will reach further into our solar system and provide critical knowledge about our home planet.

Among other science goals, the budget will sustain NASA's vital role in helping us understand Earth system and climate and the dynamics between our planet and our sun. These efforts will provide critical knowledge about our home planet and potential threats.

We will continue our steady progress toward our next great observatory as we develop the James Webb Space Telescope scheduled to launch in 2018. NASA's program of innovative aeronautics research is pursuing an ambitious research agenda for substantially reducing aircraft fuel consumption, emissions and noise. With the 2014 request, NASA begins a new $25 million-a-year advanced composites project that will focus on innovative composite materials and structures.

Mr. Chairman, we have had to make some pretty tough choices with this budget, but I am committed to making sure NASA is using its resources strategically for a cohesive exploration program that bolsters our economy, improves life on Earth and raises the bar of what humans can achieve.

I look forward to your questions.

[The prepared statement of General Bolden follows:]

HOLD FOR RELEASE
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BY WITNESS
April 24, 2013

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

before the

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

Mr. Chairman and Members of the Committee, I am pleased to have this opportunity to discuss NASA's FY 2014 budget request. The requested budget of $17.715 billion will support continuing progress toward implementing the bi-partisan program for NASA agreed to by the President and Congress, which will ensure the United States continues to lead the world in space exploration, technology, innovation, and scientific discovery. A summary of the FY 2014 budget request is appended to this statement.

American astronauts are living and working in space on board the International Space Station (ISS), conducting an expanding research program with an array of partners. By partnering with American companies, we are cost-effectively resupplying the space station from U.S. soil, and we are on track to end our sole reliance on Russia for astronaut transport to and from the Space Station by 2017. NASA is developing spaceflight capabilities to send humans to an asteroid by 2025 and on to Mars in the 2030's. To accomplish these goals, we are building the world's most powerful rocket, the Space Launch System (SLS), and a deep space exploration crew vehicle, the *Orion* Multi-Purpose Crew Vehicle (MPCV). In critical support of the Agency's broader mission, we are developing and testing space technologies that will enable us to move and operate faster and more efficiently in space, land more mass accurately on another planet, and enable new destinations to be visited. These technologies include solar electric propulsion, learning to store and transfer fuel in orbit, radiation protection, laser communications, high-reliability life support systems, and human and robotic interfaces. Our aeronautics research is making air travel cleaner, safer, and more efficient. With many missions actively observing Earth, the planets, the Sun, and the Universe, we remain the world's premier space science organization and the critical source of information for an understanding of Earth's climate that can only be gained from the global perspective of space. We are extending these cutting-edge capabilities with major new developments, including the James Webb Space Telescope and a new Mars rover. Despite an uncertain budget climate, NASA is delivering the world's preeminent space program, supporting an innovation economy, and broadening our understanding of the universe around us.

As is briefly described below, NASA's resources are directed to accomplish the goals set for the Agency by the Congress and the President. Our improved processes for cost estimating and program management play a critical role in our ability to manage our resources, and we remain on track in our major developments. NASA is confident that we can continue to execute the program described below within the budget levels anticipated in the President's FY 2014 request for NASA. We will attempt to maintain and implement long-term development plans within future budgets as they are appropriated. The Agency stands committed to executing our programs as efficiently as possible.

An Integrated Exploration Mission
The President's Fiscal Year 2014 budget request continues to implement the bi-partisan strategy for space exploration approved by Congress in 2010, a plan that advances U.S. preeminence in science and technology, improves life on Earth, and protects our home planet, all while helping create jobs and strengthening the American economy. This budget reflects current fiscal realities by aligning and leveraging relevant portions of NASA's science, space technology, and human exploration capabilities to achieve the President's challenge of sending astronauts to an asteroid by 2025.

As part of the agency's overall asteroid strategy, NASA is planning a first-ever mission to identify, capture, and redirect an asteroid into orbit around the Moon. The overall mission is composed of three separate and independently compelling elements: the detection and characterization of candidate near-Earth asteroids; the robotic rendezvous, capture, and redirection of a target asteroid to the Earth-Moon system; and the crewed mission to explore and sample the captured asteroid using the Space Launch System (SLS) and the *Orion* crew capsule. This mission represents an unprecedented technological challenge -- raising the bar for human exploration and discovery, while helping protect our home planet and bringing us closer to a human mission to Mars in the 2030s.

Each mission element would heavily leverage on-going activities across the Human Exploration and Operations, Space Technology, and Science Mission Directorates. We are currently working to align on-going activities across these directorates to affordably achieve the objectives while we plan this mission. Progress will continue conditional on feasibility and affordability. Funding provided within the President's FY2014 budget request will augment our existing activities in Space Technology, Science, and Human Exploration and Operations to: enhance our near-Earth asteroid detection and characterization assets; accelerate advanced solar electric propulsion development; and design and test capabilities to capture a small, yet slowly tumbling asteroid in space.

Science
With 60 missions observing Earth, the Sun, the planets, and the Universe, NASA remains the world's premier space science organization and the critical source of information on the home planet. NASA's Budget request for the Science Mission Directorate includes $5,017.8 million with $1,846.1 million for Earth Science, $1,217.5 million for Planetary Science, $642.3 million for Astrophysics, $658.2 million for the James Webb Telescope, and $653.7 million for Heliophysics.

Earth Science
Seventeen NASA Earth Science research missions currently in orbit study the home planet as an integrated system, including the recently launched Landsat Data Continuity Mission (LDCM), which is undergoing on-orbit checkout. NASA is also beginning work on land imaging capabilities beyond LDCM as well as climate sensors that were previously part of the Joint Polar Satellite System (JPSS). NASA missions continue to give us a global perspective on how Earth works as a system and how our climate is changing over time. Few products of NASA's research can be as valuable, in a material sense, as an accurate understanding of the future of our planet's environment – on land, in the oceans, and throughout the atmosphere. The FY 2014 request supports the launch of two new Earth science missions in FY 2014, and final preparations for launch of two more before the end of the calendar year. The Global Precipitation Measurement (GPM) mission, a cooperative mission with the Japan Aerospace Exploration Agency (JAXA), will provide unprecedented global precipitation observations and the Orbiting Carbon Observatory-2 (OCO-2) will provide accurate global measurements of atmospheric carbon dioxide levels. In the fall of 2014, NASA will launch the Soil Moisture Active Passive (SMAP) mission to study the Earth's hydrologic cycle. At the end of the calendar year, in a collaboration among NASA's Science Mission Directorate, Human Exploration and Operations Mission Directorate, and the European Space Agency; NASA will launch and install the Stratospheric Aerosol and Gas Experiment III

(SAGE III) on the ISS to continue critical long-term measurements of the vertical structure of aerosols, ozone, water vapor, and other important trace gases in the upper atmosphere.

Astrophysics and James Webb Space Telescope
NASA is on track and making excellent progress on the James Webb Space Telescope, the most powerful space telescope in history. The Webb telescope is the next in a series of astrophysics missions, including the venerable, yet still unrivaled Hubble Space Telescope 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 kelvins). The Webb telescope will allow us to observe objects even fainter than the Hubble Space Telescope can see, which will allow us to study every phase in the history of our universe, ranging from the first luminous glows after the Big Bang, to the formation of solar systems capable of supporting life on planets like Earth, to the evolution of our own solar system. The FY 2014 request will support work to finish the Webb science instruments, begin their testing as an integrated science payload, and commence construction on the spacecraft that will carry the science instruments and the telescope. NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) airborne observatory is making its second year of science observations. Operating at altitudes of between 39,000 to 45,000 feet (12-14 kilometers) and above 99 percent of the water vapor in the atmosphere, SOFIA makes observations that are unobtainable from telescopes on the ground. In the coming year, SOFIA will begin its next set of science observations. Flying out of Palmdale, California, and Christchurch, New Zealand, SOFIA will observe star-forming regions in our galaxy from its vantage point at the top of the Earth's atmosphere.

Planetary Science
Building on the brilliant success of NASA's new *Curiosity* rover on Mars, the 2014 request supports plans for a robust multi-year Mars program, including a new robotic science rover based on the *Curiosity* design set to launch in 2020. The current portfolio includes the *Curiosity* and *Opportunity* rovers, the Mars Recognizance Orbiter, the Mars Odyssey orbiter, and our collaboration with the European Space Agency Mars Express orbiter. Future missions include the 2013 Mars Atmosphere and Volatile EvolutioN (MAVEN) orbiter to study the Martian upper atmosphere; 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.

Last summer, NASA's Dawn mission completed more than a year in orbit around the asteroid Vesta, and departed for its 2015 rendezvous with Ceres, the largest known asteroid. NASA is developing a robotic asteroid rendezvous and sample return mission, dubbed OSIRIS-REx (for Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer), which is planned to launch in 2016. After traveling three years, OSIRIS-REx will approach the Near Earth Asteroid 1999 RQ36, map the asteroid, and collect a sample of up to 2.2 pounds for return to Earth. This mission will provide valuable data and experience in support of NASA's planned human exploration of a Near Earth Asteroid. In addition, the FY14 budget request includes enhanced funding for NASA's Near Earth Object survey and characterization activities in support of human exploration and to protect our planet.

Heliophysics
Perhaps even more dynamic than the Earth's climate are the processes taking place within the Earth's nearby star, the Sun. NASA's Heliophysics Program operates nearly 20 spacecraft to expand our understanding of the Sun, its complex interaction with Earth, other planetary systems, the vast space within the solar system, and the interface with interstellar space. Last year saw the successful launch of the Van Allen Probes, which, in a few short months, have already redefined our understanding of the Earth's radiation belts. The FY 2014 request will support final development and launch of the Interface

Region Imaging Spectrograph (IRIS), as well as continued development of the Magnetospheric Multiscale (MMS) mission, which is planned for launch in 2015 to investigate how the Sun's and Earth's magnetic fields connect and disconnect. NASA continues to formulate the Solar Probe Plus (SPP) mission and develop its contribution to the European Space Agency's Solar Orbiter mission.

Aeronautics Research
NASA's FY 2014 request includes $565.7 million for NASA's program of innovative aeronautics research. This research supports the Nation's aviation industry's efforts to maintain competitiveness in the global market, and helps to provide the flying public with an improved flying experience and fewer delays, while also maintaining an outstanding safety level. NASA's breakthrough research into more efficient air traffic management and environmentally friendly aircraft helps U.S. air carriers to operate their fleets more efficiently while reducing operating costs. Today, we are pursuing an ambitious research agenda for substantially reducing fuel consumption, emissions and noise to make the Next Generation Air Transportation System (NextGen) a reality. NASA begins a new $25 million a year Advanced Composites Project in FY 2014 that will focus on reducing the timeline for development and certification of innovative composite materials and structures. Looking ahead, NASA is paving the way for further industry innovation through demonstration in flight of new aircraft wing technology designed to save fuel by reducing weight and drag, and continued flight research of low-boom technology designed to reduce sonic booms enough to eliminate the barrier to overland civil supersonic flight. By advancing the state of the art in vehicle and air traffic management technology, NASA is directly contributing to the Nation's bottom line.

Space Technology
NASA's FY 2014 request includes $742.6 million for Space Technology. Space Technology enables our future in space by drawing on talent from the NASA workforce, academia, small businesses, and the broader national space enterprise to deliver innovative solutions that dramatically lower costs and improve technological capabilities for NASA and the Nation. In 2012, we successfully fabricated a 2.4 meter composite cryogenic propellant tank. We will scale this design up and test a 5.5-meter diameter tank to enable lower-mass rocket propellant tanks that will meet future SLS needs. The Small Businesses Innovation Research and Small Business Technology Transfer (SBIR and STTR) programs saw six previously funded technologies make their way to Mars last August with the landing of Curiosity and provide the critical detector in the infrared instrument on the LDCM spacecraft. In 2013, we will fly a cluster of eight small satellites that will make coordinated space science observations. We will conduct high-altitude tests of the largest planetary parachute ever developed and drag devices designed to enable precise landing of higher-mass payloads to the surface of planets, with particular focus on infusing advanced capabilities into the Mars 2020 mission. In addition, NASA will launch the Sunjammer Solar Sail, which will demonstrate solar sail propulsion as an enabler for advanced space weather warning systems. Space Technology is also systematically addressing technology barriers in preparation for a future solar electric propulsion demonstration to an asteroid. By the end of FY 2014, NASA will test and deliver two candidates for large deployable solar array systems, power processing units, and advanced thrusters to support this flight demonstration. The Game Changing Program is delivering advanced life-support, robotics, and battery technologies for the system demonstrations planned by the Advanced Exploration Systems Division of NASA's Human Exploration and Operations Mission Directorate.

To meet the challenges that we face in implementing our exploration plans, we are engaging the Nation's brightest and best. Over the past two years, Space Technology has engaged over 100 U.S. universities and academic institutions with approximately 350 activities, including fellowships, direct competitive awards, incentive prizes, and through partnerships with NASA Centers, small businesses, and commercial contractors. The FY 2014 request will support our plans to continue releasing a steady stream of new solicitations, tapping into the Nation's talent to ensure the availability of advanced technologies for NASA's missions and ultimately, through technology transfer, for American businesses. Following the

National Research Council's review of NASA's Space Technology Roadmaps, the Agency released and is implementing the Strategic Space Technology Investment Plan, which guides technology priorities across the agency's space-technology portfolio across its mission directorates. NASA's community of innovators is applying, testing, and reworking cutting-edge research into potentially "game-changing" solutions that can accelerate a timeline, slash projected costs, or multiply science return. NASA makes progress in essential space technologies daily, enabling more capable and far-reaching space systems for our Nation's future, and we are doing so through lean, agile programs and innovative approaches.

Exploration and Space Operations

NASA is building the capabilities and knowledge to send humans farther from the home planet than we have ever been before. The FY 2014 budget request for Exploration is $3,915.5 million with $2,730 million for Exploration Systems Development, $821.4 million for Commercial Space Flight, and $364.2 million for Exploration Research and Development. Space Operations, including the International Space Station and Space Flight Support form a critical component or 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 2014 request for Space Operations is $3,882.9 million.

Exploration Systems

The FY 2014 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* Multi-Purpose Crew Vehicle (MPCV) program continues on schedule for an uncrewed test flight in 2014. This test flight, Exploration Flight Test-1 (EFT-1), will see *Orion* conduct two orbits of Earth and reenter the atmosphere at a high-speed characteristic of a returning deep space exploration mission. The test will provide valuable data about the spacecraft's systems, most importantly, its heat shield. The flight test article for this mission is already in place at the Kennedy Space Center and being readied for this test. The FY 2014 request supports progress toward a first uncrewed test of the *Orion* and the SLS together, known as Exploration Mission-1 (EM-1) in 2017, with the first crewed mission of the two vehicles slated for 2021. These two missions will test and demonstrate these systems. Together, the SLS and *Orion* MPCV represent a critical step on the path to human deep space exploration. Because our commercial space partners continue to make rapid and cost-effective progress toward meeting the Agency's requirements for access to the ISS and to low Earth orbit, NASA is able to focus its human exploration resources to develop the deep space capabilities represented by the SLS and *Orion* MPCV.

International Space Station

The FY 2014 request supports the International Space Station (ISS) with its international crew of 6 orbiting Earth every 90 minutes. The Station is making deep space exploration possible, building on the knowledge and experience we are gaining from the astronauts living, working, and conducting research on the ISS. Our plans for the coming year include preparing for an extended duration, year-long human-crewed mission to explore human adaptation to space; continuing to utilize the ISS to improve our ability to live and work in space, including technology demonstrations enabling future exploration; and the addition of three Earth Science instruments that will exploit ISS' capabilities to study winds over the oceans and the movement of dust, smoke, and pollution through the atmosphere. The Center for the Advancement of Science in Space (CASIS) is now managing 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.

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 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 space station, and Orbital Sciences Corporation (Orbital) was awarded 8. SpaceX executed its first cargo mission to the ISS in October 2012, successfully delivering its cargo and returning scientific samples to Earth. SpaceX successfully completed its second CRS mission and its Dragon spacecraft safely returned to Earth on March 26. Orbital successfully completed the maiden flight of its *Antares* rocket on April 21st and will conduct a demonstration flight of the *Antares* with the Cygnus spacecraft this spring under the Commercial Orbital Transportation Services (COTS) effort. Orbital's first contracted cargo resupply mission under CRS is slated for later this year. NASA continues to work with its commercial partners to develop a U.S. commercial capability for human spaceflight. NASA intends to procure commercial crew services to ISS by 2017, and full funding of the FY 2014 request is essential to restore a human spaceflight capability to the United States in this timeframe. Through the successful execution of this partnership, we will return to the United States the vital capability to launch astronauts to the ISS and return them to Earth.

Education

NASA supports the President's goal to utilize existing resources to achieve improvements in science, technology, engineering, and mathematics, or STEM, education and instruction. The Administration is proposing a comprehensive reorganization of STEM education investments. The 2014 Budget will enhance the impact of the Federal investment by reorganizing STEM education programs across agencies and redirecting funding in support of a cohesive national STEM strategy focused on four priority areas: K-12 instruction; undergraduate education; graduate fellowships; and informal education activities. Within NASA, STEM education investments previously distributed across the Agency will be consolidated and focused within the Office of Education, the National Science Foundation, and the Smithsonian Institution. During FY 2013 and FY 2014, NASA's education teams will develop transition plans that minimize impacts to students and organizations currently served by NASA. The Agency will also conduct studies to determine which NASA education assets should and can be made available to the new STEM consolidation partners.

The FY 2014 request of $94.2 million includes education activities in the Office of Education and NASA's mission directorates. The funding 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 Program (MUREP). 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. Starting in FY 2014, mission-based K-12 education, and engagement activities, traditionally funded within programmatic accounts, will be incorporated into the Administration's new STEM education paradigm.

Cross Agency Support

NASA's Cross Agency Support (CAS) account funds all of the operations and maintenance of NASA's nine Centers, component facilities, and Headquarters, including, the Agency's safety offices, independent technical authority, NASA's engineering safety center, procurement, and others that oversee activities to reduce the risk and loss of life and/or mission in all of NASA's human, satellite, aeronautic, and robotic programs. NASA's FY 2014 request of $2.85 billion supports critical efforts to modernize NASA's information technology security processes and expanding security operations efforts to provide early warning of cyber vulnerabilities. The request will support the Agency's continuing efforts to reduce its facilities costs by consolidating capabilities and disposing of unneeded assets.

Conclusion

NASA thrives on the synergy created by a critical mass of brilliant scientific and engineering talent, supported by a broad range of expert professionals. We work, as an Agency, to send humans to an asteroid and on to orbit Mars. We work, as an Agency, to understand the universe from the beginning of

time to the future of Earth's climate. The people working to put the next rover on Mars are refining the systems necessary to put humans there in the future. The people testing advanced ring-sail parachutes for landing payloads on planetary surfaces are also learning how flight through an atmosphere at super-high speeds works. The astronauts running physical science experiments on the ISS are themselves life science experiment subjects, and at the same time, they are demonstrating the science and technology for living and working in space. The Agency is on track and making steady progress executing the space and aeronautical program defined for us by Congress and the President in the 2010 Authorization Act, and we are confident we can accomplish these programs under that direction. NASA's confidence that we can execute the program described here is based primarily on the demonstrated expertise, flexibility, and dedication of our people. The reason why NASA ranks as the best place to work in the Federal government may simply be this: we all are contributors to a mission greater than ourselves, extending beyond the current generation. We tackle national and global challenges. We are explorers.

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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National Aeronautics and Space Administration

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

	Fiscal Year						
	Actual	Estimate	Request	Notional			
Budget Authority ($ in millions)	2012[1]	2013[2]	2014	2015	2016	2017	2018
NASA FY 2014	17,770.0	17,893.4	17,715.4	17,715.4	17,715.4	17,715.4	17,715.4
Science	5,073.7	5,115.9	5,017.8	5,017.8	5,017.8	5,017.8	5,017.8
Earth Science	1,765.7		1,846.1	1,854.6	1,848.9	1,836.9	1,838.1
Planetary Science	1,501.4		1,217.5	1,214.8	1,225.3	1,254.5	1,253.0
Astrophysics	648.4		642.3	670.0	686.8	692.7	727.1
James Webb Space Telescope	518.6		658.2	645.4	620.0	569.4	534.9
Heliophysics	644.9		653.7	633.1	636.8	664.3	664.6
Subtotal, Science	5,079.0	5,121.1	5,017.8	5,017.8	5,017.8	5,017.8	5,017.8
Less Rescissions	(5.3)	(5.3)					
Aeronautics	569.4	572.9	565.7	565.7	565.7	565.7	565.7
Subtotal, Aeronautics	569.9	573.4	565.7	565.7	565.7	565.7	565.7
Less Rescissions	(0.5)	(0.5)					
Space Technology	573.7	577.2	742.6	742.6	742.6	742.6	742.6
Subtotal, Space Technology	575.0	578.5	742.6	742.6	742.6	742.6	742.6
Less Rescissions	(1.3)	(1.3)					
Exploration	3,707.3	3,790.1	3,915.5	3,952.0	3,970.7	3,799.0	3,589.3
Exploration Systems Dev	3,002.0		2,730.0	2,789.8	2,801.5	2,818.3	2,819.5
Commercial Spaceflight	406.0		821.4	821.4	821.4	590.0	371.0
Exploration Research & Dev	303.0		364.2	340.8	347.8	390.7	398.7
Subtotal, Exploration	3,711.0	3,793.9	3,915.5	3,952.0	3,970.7	3,799.0	3,589.3
Less Rescissions	(3.7)	(3.7)					
Space Operations	4,184.0	4,249.1	3,882.9	4,014.9	3,996.2	4,167.9	4,377.6
Space Shuttle	599.3		0.0	0.0	0.0	0.0	0.0
International Space Station	2,789.9		3,049.1	3,169.8	3,182.4	3,389.6	3,598.3
Space & Flight Support	805.2		833.8	845.1	813.8	778.3	779.3
Subtotal, Space Operations	4,194.4	4,259.4	3,882.9	4,014.9	3,996.2	4,167.9	4,377.6
Less Rescissions	(10.4)	(10.4)					
Education	136.1	136.9	94.2	94.2	94.2	94.2	94.2
Subtotal, Education	138.4	139.2	94.2	94.2	94.2	94.2	94.2
Less Rescissions	(2.3)	(2.3)					
Cross Agency Support	2,993.9	3,012.2	2,850.3	2,850.3	2,850.3	2,850.3	2,850.3
Center Management & Ops	2,204.1		2,089.7	2,089.7	2,089.7	2,089.7	2,089.7
Agency Management & Ops	789.9		760.6	760.6	760.6	760.6	760.6
Subtotal, Cross Agency Support	2,994.0	3,012.3	2,850.3	2,850.3	2,850.3	2,850.3	2,850.3
Less Rescissions	(0.1)	(0.1)					

National Aeronautics and Space Administration

FY 2014 PRESIDENT'S BUDGET REQUEST SUMMARY

Budget Authority ($ in millions)	Fiscal Year						
	Actual 2012[1]	Estimate 2013[2]	Request 2014	Notional 2015	Notional 2016	Notional 2017	Notional 2018
Construction & Environmental Compliance & Restoration[3]	494.5	401.9	609.4	440.9	440.9	440.9	440.9
Construction of Facilities	455.0		533.9	365.4	365.4	365.4	365.4
Environmental Compliance & Restoration	45.0		75.5	75.5	75.5	75.5	75.5
Subtotal, Construction & Environmental Compliance & Restoration	500.0	407.4	609.4	440.9	440.9	440.9	440.9
Less Rescissions	(5.5)	(5.5)					
Office of Inspector General[4]	38.3	38.2	37.0	37.0	37.0	37.0	37.0
Subtotal, Inspector General	38.3	38.5	37.0	37.0	37.0	37.0	37.0
Less Rescissions	0.0	(0.3)					
Less Rescission from Prior Appropriation Accounts	(1.0)	(1.0)					
NASA FY 2014	17,770.0	17,893.4	17,715.4	17,715.4	17,715.4	17,715.4	17,715.4

[1]FY 2012 rescissions are pursuant to PL 112-55, Division B, sec 528(f).

[2]The FY 2013 appropriation for NASA was not enacted at the time that the FY 2014 Request was prepared; therefore, the amounts in the FY 2013 column reflect the annualized level provided by the Continuing Resolution plus the 0.612 percent across the board increase (pursuant to Section 101(a) and (c) of P.L. 112-175). The FY 2012 and 2013 column also include rescissions to prior-year unobligated balances pursuant to P.L. 112-55, Division B, sec. 528(f).

[3]Construction and Environmental Compliance and Restoration includes $15 million provided by the Disaster Relief Act, 2013 (P.L. 113-2) for Sandy storm recovery.

[4]Rescission of unobligated American Recovery and Reinvestments Act balances in the Office of Inspector General account pursuant to P.L. 111-203, the Dodd-Frank Wall Street Reform and Consumer Protection Act.

Chairman PALAZZO. I want to thank again the witness for being available for questioning today. I also want to remind Members that Committee rules limit questioning to five minutes. The Chair will at this point open the round of questions.

Administrator Bolden, under current topline funding levels, what is the cost schedule confidence level for SLS being operational by 2017?

General BOLDEN. Sir, if you are asking about the joint confidence level number, I don't think we have finished developing that yet, but I will get to it for certain. But I will say that I know it will be a number with which I will be very comfortable for a number of reasons. Unlike other brand new programs, SLS is an evolving system in which we are using previously proven hardware, if you will. The shuttle main engines are the main propulsion system for SLS in the beginning. We are using, granted, a five-segment solid-rocket motor as the initial boosters for the system, but it is still very well-proven technology. Orion has been through now two programs, Constellation and presently the Orion program itself. So we are at a level of maturity with those programs that we would not ordinarily be with another program. So I am very confident in our cost estimates.

We have had an independent cost assessment done that has been available to this Committee and Congress for about a year or so now in which they assess that our estimates were well-founded, that the process for determining what we thought the cost would be was grounded in good budgeting and cost planning. They cautioned us that we probably could use more, but as I think I have told this Committee and others before, I don't remember a time that we couldn't use more to buy down risk on any of our projects.

Chairman PALAZZO. So you don't have a joint confidence level percentage right now?

General BOLDEN. We don't have a joint confidence level percentage right now because we have not reached what we call the key decision point C which is the point at which we determine whether we are going to go forward with a program.

If that number came out to be really bad, which I don't anticipate, it might dictate that a program be cancelled. But I don't anticipate that at all.

Chairman PALAZZO. When can this Committee expect one?

General BOLDEN. Mr. Chairman, I will get back to you. I think the KDPC is sometime this summer, but I will get back. I will get that for the Committee.

Chairman PALAZZO. Well, if there is not an official joint confidence level, what would General Bolden say would be as a percentage?

General BOLDEN. Oh, yeah, that is what I said. My guess is that——

Chairman PALAZZO. A percentage.

General BOLDEN. —that my guess, and I shouldn't do this—no, let me not.

Chairman PALAZZO. Okay.

General BOLDEN. I shouldn't and I won't.

Chairman PALAZZO. Well, I just want to remind you, I mean, the SLS is one of NASA's top priorities, and we in this Committee look forward to seeing a joint level, confidence level as soon as possible.

General BOLDEN. Sure.

Chairman PALAZZO. The Administration's budget request for the Space Launch System includes a reduction of $60 million. How was this reduction calculated?

General BOLDEN. Mr. Chairman, let me make sure I understood. Were you saying that the budget shows a $60 million decrease——

Chairman PALAZZO. Decrease, correct.

General BOLDEN. —in SLS, in the vehicle itself?

Chairman PALAZZO. Yes, sir.

General BOLDEN. From the beginning, we used to give you one line for SLS, and every time we came back with a budget, there was always a lot of confusion and okay, that is less money than we told you to spend on SLS. So we now have started breaking out the system into the vehicle itself which is SLS, Exploration Ground Systems, which is included in 21st Century Launch Complex at the Kennedy Space Center, its construction of facility upgrades at Stennis, and we try to break those out individually now. So while there may be what seems to be a reduction in funding deliberately applied to the vehicle, I think our budget numbers have been relatively consistent from what the Human Exploration and Operations Mission Directorate has said we needed for the program from the very beginning.

Chairman PALAZZO. Can you identify the parts of the program that we are either eliminating or reducing?

General BOLDEN. We are not eliminating anything. To my knowledge, we are not reducing anything in the program, but what we are trying to do is more definitively document the amount of money that is going toward the B–2 test stand upgrades at the Stennis Space Center. That was not spelled out in the budget before, and now when you look under what we call CECR, the construction of facilities account, you will see a specific reference to the B–2 test stand, you will see a specific reference in the write-ups to advanced boosters which we think is very critical, not to the 70-metric ton version of SLS, but we will need it when we move up to 150-metric ton version, and we can't wait until we need it in 2025 to start constructing it.

So those are numbers that I count toward SLS but the Committee may not attribute to SLS.

Chairman PALAZZO. So just to clarify, with the reduced funding, you don't see any anticipated missed deadlines for SLS.

General BOLDEN. I don't see, anticipate any missed deadlines, and I would remind the Committee, and I think, Mr. Chairman, you know probably better than anybody sitting in this room because you have seen more than I have at Stennis, we have been testing the J2–X consistently at Stennis very successfully. We have got 500 second tests several times now. We are running tests at ATK with the boosters. We have gotten Orion where it is ready. It is almost ready to fly in the fall of 2014. We could tick off the achievements in both SLS and Orion that meet our milestones, and we have not—with one exception that I know of which is delaying or putting off the abort, the Airborne abort test, for Orion, which

we don't need for many years. We delayed that so that we could get some other things done.

Chairman PALAZZO. Okay. I now recognize Ms. Edwards for five minutes.

Ms. EDWARDS. Thank you, Mr. Chairman. I have a statement that is submitted by the Planetary Society expressing concerns about the Fiscal Year 2014 budget that I would like to request be entered into the record.

Chairman PALAZZO. Without objection, so ordered.

[The information appears in Appendix II]

Ms. EDWARDS. Thank you, Mr. Chairman. General Bolden, I want to start by asking you about your budget because it seems that it assumes that the sequestration will end. And so I want to know what you believe would happen if sequestration continues to affect the NASA budget in 2014 and beyond, and what would be the likely impacts and have you thought about the planning for that in terms of new initiatives in Fiscal Year 2014 such as the asteroid mission? Would that be eliminated? How would you translate your priorities for 2014 into funding decisions in the event that sequestration continues?

General BOLDEN. Congresswoman, first of all, let me confirm your assumption about the budget itself. The 17.7 is based on the President's confidence that he will be able to work out an agreement with this Congress in the budget for Fiscal Year 2014 that will negate the sequester. So that is a correct assumption.

If this Congress and the Administration are unable to do what the American public expects and we have to deal with sequestration for a ten-year period of time, to be quite candid, all bets are off. And things that we talk about, what I do now, when I come to this Committee and say we are fully funding all of our priorities, I can't do that. It puts more than 20 pounds in a 5-pound sack, and we will not be able to do that. Examples would be some of the testing that is necessary for our Commercial Crew Program will have to slip. Several of you have referenced the amount of money that we consistently ask for for Commercial Crew Program and say why do we keep doing that. The reason we keep asking for at first $1 billion annually for the Commercial Crew Program, and then we decided, okay, maybe we can make it for $822 million. What I explained to the Committee four years ago was if we don't get back then it was a billion dollars, we won't be able to deliver Commercial Crew Program in 2014.

Ms. EDWARDS. What about the asteroid mission? What happens to that?

General BOLDEN. The asteroid mission will probably go away. Congresswoman we are in the stage of developing the asteroid mission. The President requested, $105 million for a strategy. Everyone needs to understand, that is not the mission. It is an asteroid strategy that includes $78 million for the development of the mission itself in the Human Exploration and Operations Mission Directorate.

Ms. EDWARDS. So General Bolden, let me ask you about that because in the National Academy's 2012 report on NASA's strategic direction found that there is actually little support for an asteroid mission in the science community. What is your overall objective

and your testimony as you have just described refers to an overall asteroid strategy. Can you describe that strategy and if you don't have it here, can you give it to us for the record?

General BOLDEN. I can describe it because it is relatively simple, and I would have to refer back to the April 18 hearing. I think it was April 18 when we met on asteroids. Dr. John Holdren, General Shelton, and me and I think it was—I can't remember whether it was Congressman Brooks or Congressman Posey to whom I responded after much of their frustration that the only thing we could do today was pray. The asteroid strategy gives us the capability of being able to increase the number of asteroids that we identify that threaten Earth, to characterize them such that we can determine how we reach them. We are developing a process or a technology that will come forward in the Asteroid Retrieval Mission that will demonstrate that humans can, in fact, alter the path of an asteroid that is headed toward Earth.

So these are very important parts of the asteroid strategy. It is—

Ms. EDWARDS. Let me just interrupt you for a minute.

General BOLDEN. Yes.

Ms. EDWARDS. I apologize. But are you saying to us then that the goal is an asteroid and a capture and retrieval of an asteroid? Or is the goal an interim step to Mars?

General BOLDEN. The goal of our program is to remain the world's leader in space exploration to meet the President's goal for us, or challenge for us, of putting humans in Martian orbit in the 2030s. That is the ultimate destination for humans, and we must not lose track of that.

An asteroid is an intermediate destination on the way to our ultimate destination of Mars. An asteroid mission must stand by itself, however. So as a part of the strategy, the asteroid mission answers several other questions that have been asked of us or challenges that have been given us. Putting a human with an asteroid. That is one that the President expressed to us. This Committee and others in this Congress and the National Space Policy demands that we be able to identify, as you said, 100 percent of the asteroids that are 40 meters or less, and this is one of the ways that we intend to move toward answering those questions for the Nation.

Ms. EDWARDS. Thank you, Mr. Chairman. I hope we will be able to get to follow-up with this. Thanks.

Chairman PALAZZO. Thank you, Ms. Edwards. We are going to try to get through as many Members as possible, but then we are going to recess for votes. But we are also going to return, so I now recognize Mr. Smith for five minutes.

Chairman SMITH. Thank you, Mr. Chairman. It sounds like a number of us have the same type of questions, and Mr. Bolden, you should not take these personally if we ask tough questions because I think we all admire you as an administrator and appreciate the job you are doing.

Let me go to the Asteroid Retrieval Mission and follow up on that. NASA's Small Bodies Advisory Group reported, "While the participants found it to be very interesting and entertaining, it was not considered to be a serious proposal." Why would the Administration dismiss the advice of those whose advice they sought?

General BOLDEN. I am not aware of that advice, to be quite honest. That is the first—I just haven't seen that, sir.

Chairman SMITH. Really? That Small Bodies Advisory Group——

General BOLDEN. I know what the Small Bodies Advisory Group is. I am saying I am not aware that they offered that. I have in my possession the letter from the Planetary—everybody generally cc's me on everything that comes to Congress so I won't be surprised.

Chairman SMITH. That was——

General BOLDEN. I am surprised by this.

Chairman SMITH. That was a direct quote. I will get it to you——

General BOLDEN. Yes, sir.

Chairman SMITH. —soon then. The other question, this follows up a little bit as well. Everything I have seen makes me believe that scientists and others who are experts think that a Moon landing rather than a rendezvous with an asteroid is a better precursor to a Mars mission. Would you agree with that or do you think the asteroid is better preparation?

General BOLDEN. Congressman, I would agree with anyone who says that a Moon landing is good. We have done it. We have done it six times, and it was incredibly good.

Chairman SMITH. There is a lot more to do than what we have done so far.

General BOLDEN. There is so much more to do than what we have done so far. But if I go back to the premise that the Chairman opened up with that we can only do so much.

Chairman SMITH. Which would be better for the Mars mission? Would it be back to the Moon or would it be the asteroid?

General BOLDEN. I don't think that either would be better. They both are good. In our particular case since we are operating under a flat budget. The one that is executable in today's budget environment is an asteroid mission.

Chairman SMITH. If various experts said the Moon, would you heed their advice?

General BOLDEN. We get expert advice all the time, and we try to heed. However, I think you know, Mr. Chairman, it is impossible to heed the advice of all experts. Some expert is going to feel that he or she is being disregarded. I have utmost respect for the National Research Council Committee that looked at us and said——

Chairman SMITH. Pretty soon——

General BOLDEN. —that there was—asteroids.

Chairman SMITH. —on some subject you are going to have to take the expert's advice, whether it be from Small——

General BOLDEN. We are taking the advice of experts with this.

Chairman SMITH. Whether it be from the Small Bodies Advisory Group or for others saying that the lunar mission would be better for the Mars mission.

My next question is this. On the James Webb Space Telescope, which is one of our great scientific adventures, there is some concern about technical problems there. I think it is maybe overweight. I think there are two instruments that are running close to a year behind. Do you see us able to meet our deadlines and get the James Webb up in fall, I think, 2017 as expected?

General BOLDEN. Chairman Smith, I would——

Chairman SMITH. 2018.

General BOLDEN. Again, I would have to ask for the source of the information. That is in direct contrast to what I get every week in terms of status of James Webb. We are 14 months ahead on the critical path toward flight.

Chairman SMITH. So you are not——

General BOLDEN. So for someone to say that we are a year behind with two instruments. We have two instruments that we have been working quite a bit. The vendors have delivered NIRCam and NIRSpect, and if they think they are a year behind, I need to know it.

Chairman SMITH. Well 11 months behind is what I am told.

General BOLDEN. If they think we are 11 months behind on those two instruments——

Chairman SMITH. I keep coming up with all these news breaks.

General BOLDEN. Sir, that is a serious newsbreak because that would be contradictory to what the leadership of Northrup Grumman and NASA's James Webb Space Telescope program are telling the administrator.

Chairman SMITH. We will——

General BOLDEN. That is not a——

Chairman SMITH. We will get you our——

General BOLDEN. That is a serious absence of information to me if that is true.

Chairman SMITH. Okay. We will get you our source on that as well.

General BOLDEN. Yes, sir. I would appreciate that because I promised this Congress that I was responsible for the James Webb Space Telescope. I think you may remember when I stood here and I said no one feels as bad about this as I do.

Chairman SMITH. The information that I just mentioned, the two instruments being 11 months delayed, was in a GAO report that came out last week.

General BOLDEN. I would have to go back and check with my—we have carried GAO by the hand through Goddard, through the Johnson Space Center and everywhere. So if GAO is reporting that we have instruments that are 11 months behind——

Chairman SMITH. This is GAO, April 2013, two of the instruments, 11 months behind.

General BOLDEN. Mr. Chairman, I will get back to you.

Chairman SMITH. Okay.

General BOLDEN. That is news to me.

Chairman SMITH. Okay. Thank you. Last quick question. I want to go back to what the Chairman mentioned about SLS beginning operations by 2017 as hoped. Do you think that is very guaranteed, very likely or probable?

General BOLDEN. I think if this Congress and the Administration are able to solve the sequester problem, 2017 inaugural flight on the integrated SLS on Orion is very good. Nothing is ever a certainty in this business. Barring no accidents, barring a successful flight of Orion next year, we are well on the way to a 2017 inaugural flight of SLS on Orion.

Chairman SMITH. Thank you, Mr. Bolden. Thank you, Mr. Chairman.

Chairman PALAZZO. Thank you, Mr. Smith. I now recognize Mr. Kennedy for five minutes.

Mr. KENNEDY. Thank you, Mr. Chairman. General, thank you very much for being here. I thank the Committee for calling the important hearing.

General, just a couple of questions for you. I understand—shifting gears a little bit from the asteroid mission to something that is near and dear to my district is the STEM education programs that you have at NASA, and I understand from the budget materials that there has been a reorganization and a consolidation of some of those priorities for the Administration, focusing on four priority areas and consolidating programs into three different agencies.

So my question to you, sir, is, is there any thought on how this transition is going to—well, you can minimize the disruption to some of these programs that are extraordinarily popular and important to school children as young as kindergarteners. In my district, there is a number of education programs that have been extraordinarily successful. I was at one recently in Sharon. There was about 1,200 students learning about space and STEM training to be an astronaut. One of the high schools, the Tri-County High School in Franklin, was one of only eight highs schools in the country that were selected to participate in United with NASA to create a hardware program last year, a far more interesting science class than I ever took, building robots, trying to come up with ways for astronauts to scramble eggs in space which I am sure is probably something useful to you.

So how can we ensure, General, that programs like these that are already highly successful and are inspiring an entirely new generation of engineers don't disappear?

General BOLDEN. Congressman, in answering your question, I need to go back and tell you what I think is successful. When I became the NASA Administrator, I asked for metrics. I am not an engineer, but I play with a lot of them. And so I have learned to have an appreciation for metrics, to demonstrate that something is successful or valuable.

When I asked what the metrics were on the effectiveness on our K–12 STEM education program, I got blank stares. I was told that we touch a million kids a year, and I said, okay, I got it. But what effect have we had on those 12 million kids? Did I take one who was not interested in science and have them, when they get to high school, take very difficult science and math courses and go to college and major in engineering? And the answer I got was we don't know. And I said, well, how do we know we are effective? I feel good because I go out and talk to school kids all the time. I feel great. But have I made a difference in their life? And the only way I have to know that is metrics.

The President and I happen to share this belief. And so what we are trying to do with the consolidation of the STEM education programs across the 13 or so STEM-related agencies in the government—and I see Congresswoman Edwards is smiling because she and I have talked about this at length. I think she shares my passion for metrics and demonstrating we are effective in what we do. We are not able to demonstrate our effectiveness today. The Presi-

dent is tired of it, and so he has said we are going to try something new. When you try the same thing over and over and the same answer, it is not working. You ought to try something new.

NASA is assuming a leadership role, if you will, in helping to craft this new consolidated STEM education program. And I would caution everyone. Nothing is changing right now. We have a long time remaining in this fiscal year, so the programs in existence continue to go. In NASA, programs like MUREP, EPSCoR, Space Grant, all of the critical programs that we uniquely do that reach underrepresented minorities, tribal, colleges and schools, those programs will remain, even in the consolidated program.

I don't do very well in being able to measure the effectiveness of my fellowships and scholarships. I am told the National Science Foundation has a pretty good system. So we are going to work with them to help us identify the effectiveness of our fellowships and scholarships. I don't do well at all. I have no metrics for—well, I shouldn't say that. I don't do well with metrics for K–12. I am told the Department of Education has a pretty good idea of how to establish those metrics. That is what we are working on to roll out effective the 2014 budget.

So I think the kids that we are taking care of today will be taken care of, and my hope is we will be able to show you that we have an effect, not just tell you that I feel good because I touched a million kids.

Mr. KENNEDY. Thank you.

Chairman PALAZZO. Okay. As we know, a vote has been called. The Committee will recess subject to the call of the chair which I would like to be about five minutes after the last vote in this series. Without objection, so ordered. The Committee stands in recess.

[Recess.]

Chairman PALAZZO. The Committee will now come to order. I recognize Mr. Brooks for five minutes.

Mr. BROOKS. Thank you, Mr. Chairman. First I want to make a quick comment about your focus on asteroids. Personally I concur. I think that is a good direction to go. At the same time I would add some benefit from the approach that the White House and you are recommending. First, I think it recognizes the risk to our country and our world. While at any point in time it is a small risk, over the accumulation of time it is a significant risk. Second, I think it is another reason why we need the Space Launch System to have the capability of doing whatever needs to be done. So I see it as a hand-in-glove effort. And finally, along those same lines, the technology that is developed as the history of NASA has shown, it is not limited to just one thing. The technology that NASA develops is expansive and is useful in many different ways. Whatever technology we can develop by initiating efforts with respect to asteroids I believe are beneficial.

Now to a question about the Space Launch System, as you can imagine. Thank you for coming before our Tennessee Valley Chambers of Commerce that were here on Monday. We had roughly 180 people that came to The Hill, and I was very pleased to see that you were one of the speakers, and thank you for your remarks.

Space Launch System continues to receive less than the authorized levels, yet NASA is supporting not one but three different Commercial Crew Programs, and if I am reading the President's proposed budget correctly, he is proposing a 64 percent increase in funding for Commercial Crew above the authorization bill level of $500 million, roughly from $500 million to $800 million, if the information I have is accurate.

That being the case, why the big increase for Commercial Crew but not a similar increase for Space Launch System being requested?

General BOLDEN. Mr. Chairman, not Mr. Chairman. I am sorry.

Mr. BROOKS. That is all right. If Mr. Palazzo doesn't mind, I don't mind.

General BOLDEN. Congressman, let me talk precise, exact numbers. If we took what we are requesting in the increase for Commercial Crew, which is from $525 million to $822 million, so $300 million. If I added $300 million to the SLS program, you wouldn't know it.

Mr. BROOKS. Well, I was thinking more of the 64 percent figure.

General BOLDEN. But that is my point, sir, is that it depends on the numbers you use, and if you choose to use percentages, then percentage of a number like $500 million may seem very big. It is not big at all. We are trying to get close to the level that the President asked for when he decided to fund the Commercial Crew Program, which had not been done by any previous administration to be quite candid.

We have asked for, and I think Bill Gerstenmaier, the head of the Human Exploration Operations Mission Directorate, has stated over and over that this is the amount of money that we need to deliver SLS on the date and time that we said, 2017 for the inaugural mission, integrated with Orion, 2021 now for the asteroid mission perhaps. And I don't need more money than that.

If you give me money to put against SLS, against the vehicle, it means I can't put some money that I would ordinarily put against Advanced Booster Program.

Mr. BROOKS. Given our funding limitations, do you have a concern that there may be some duplication of effort, particularly inasmuch as we are funding three different private sector contractors in the Commercial Crew environment? Do you suggest keeping it at three or reducing it to two or reducing it to one?

General BOLDEN. Congressman, our acquisition strategy, which we spelled out pretty well several years ago and we had to modify because we didn't get the money requested, was that we would try to promote competition for as long as we could and that at some point, which will be this summer, this spring, we are going to issue a draft request for proposal. The vendors will have an opportunity to look at that, tell us what they think. We will issue a final request for proposal in the fall, and by next spring we hope to be able to announce who the Commercial Crew provider is going to be.

My hope is that Congress will fully fund us to the $822 million level, and that may allow me to carry one and a half. It will not allow us to carry three vendors. If we go down to one, if I am forced to go down to one provider at any time, there is no competition,

and it is exactly as I am. It will be exactly as I am today with the Russians and—there is no competition. It went from——

Mr. BROOKS. I am running out of time, and if the Chairman would permit, I will follow up with one final question. Hopefully it will be a brief answer because it will be a brief question.

The word commercial has always been puzzling to me because I am not very familiar with a commercial or private-sector market for Commercial Crew. Do you envision that Commercial Crew is in fact going to have as its primary if not sole customer the United States Government?

General BOLDEN. I do not anticipate that. I believe industry when they say—when Boeing and Boeing's Board of Directors commit to a program as they have done with the Commercial Crew Program, they are betting on the——

Mr. BROOKS. Well, if you have any studies that suggest that there truly is a private market out there for "Commercial Crew," if you could share it with me, I would very much appreciate it.

General BOLDEN. I will make an effort to get some of the commercial companies to release what they provided to their Boards of Directors. I will try.

Mr. BROOKS. Thank you, sir.

Chairman PALAZZO. I now recognize Ms. Wilson for five minutes.

Ms. WILSON. Thank you, Mr. Chair. Good afternoon.

General BOLDEN. Good afternoon. How are you doing?

Ms. WILSON. It is my understanding that Congressman Kennedy mentioned STEM, and I would just like to follow up because I am concerned about potential funding shortfalls with regard to STEM.

As you know, training a STEM workforce is essential to our economic competitiveness, and NASA's education programs, both within its mission directorate such as science and aeronautics, are as well as within its Office of Education, have taken a significant hit in the Fiscal Year 2014 budget proposal. It is a decrease of about 46 percent from Fiscal Year 2012. Who made the decision on what education activities are proposed to be cut? Was the interagency Committee on STEM involved? And what was OMB's role?

General BOLDEN. Congresswoman, I can't tell you what OMB's role was, but I can tell you what I did. I have been intimately involved in the decisions within NASA on STEM education because I think most people will tell you no one is as passionate about STEM education as am I.

Our decision was, after we listened to the proposal that came from the President, that he wanted—as I said a little bit earlier, he wanted to find a way to make the programs effective, that we would be able to measure the effect of the STEM education programs. We decided that we would go along with that effort. We had already been part of the way down with CoSTEM that you mentioned. Their report I think is supposed to come out this summer, and we will integrate the work of CoSTEM, two years. worth, into the consolidation effort that is ongoing right now.

So I can tell you what we did. We participated in the decisions. I think what they did was across the board. It was decided to take all educational outreach funds from the agencies, the STEM agencies, to consolidate them, rather than try to cherry pick, I think we took everything, except some special ones that I mentioned earlier

that go to underserved minorities, like MURAP, EPSCoR and then Space Grant, which covers everybody.

Ms. WILSON. Just a follow-up. What resources would the Smithsonian, Department of Education and the NSF have as a part of the 2014 budget request to support infrastructure, to work across government and to implement the proposed consolidation? How would that infrastructure compare to the proven structure that NASA has developed over time which is supported through competitive selection and peer review to implement——

General BOLDEN. Yes.

Ms. WILSON. —STEM education and outreach, especially within the Science Mission Directorate? How will you do that with a 46 percent cut?

General BOLDEN. My agency is really good. We are the best place to work in government, and I don't mean that pejoratively or anything. What will happen with the consolidation is that what I can do every day, bringing downlink TV from aboard the International Space Station, taking it into a classroom, every one of the STEM-related agencies will now have access to NASA content. So that is one of the things we are giving. We will be allowing everybody else to have access to the content that we have.

What it will give us, what we will gain, will be access to the Department of Education, to the National Science Foundation and even to the Smithsonian in some of their metrics and some of their methods for promoting and reaching people with STEM education. I think there is value on both sides. Everybody gives but everybody gets something if we do it right.

Ms. WILSON. One follow-up. Who is going to oversee this? Who will oversee it? What segment of government?

General BOLDEN. The program is actually going to——

Ms. WILSON. Department of Education——

General BOLDEN. The program is actually presently being overseen by the Executive Office of the President. The President is the one that all of us are responding to in this. I am overseeing with Leland Melvin as my emissary, if you will, what we are doing in NASA. And every other principal is quite well aware of what is going on and is taking part, and we have all had an opportunity to express our opinion about how things should be done. Examples would be one of the things we proposed was take the people from each agency, each STEM agency, who are good at what they do and put them in a pool so that when the Department of Education or the National Science Foundation or Smithsonian starts looking to build a cadre of people that are going to be the overseers if you will, that we take people who have experience with this. And I expressed the desire and a willingness to offer NASA people anytime anybody wants to take them so that we make sure the program is done correctly.

Ms. WILSON. Thank you.

Chairman PALAZZO. I now recognize Mr. Stewart for five minutes.

Mr. STEWART. Thank you, Mr. Chairman. General, good to see you again.

General BOLDEN. Always good to see you.

Mr. STEWART. It has been a pleasure being on this Committee and having a chance to get to know you a little bit.

I would like to be big picture if we could for a while, and I certainly don't mean to beat a dead horse, and I don't think that we will. But help me if you could bring some clarity to I think some fundamental visions or goals of your organization, and that is with the Asteroid Retrieval Mission. What is the main objective or goal that you have there? And if I can maybe rephrase the question, help me understand why that was placed as a priority over other possibilities, say for example a manned Moon mission?

General BOLDEN. Congressman Stewart, I would not say the asteroid mission replaces anything. We did not have a lunar mission in our portfolio. We had a $17.7 billion budget with a notional, you know, five-year out that would not accommodate a lunar mission. I think it is in the record that if we went back and tried to replicate the lunar program that was in place under constellation, I have asked and I am told that Altair, the lander, is in the $8- to $10- billion range. I don't have $8 to $10 billion to put into a lander for a lunar program.

We already had solar electric propulsion underway in our Space Technology Mission Directorate. We have had that for years. We think we can accelerate it with the funds that are coming, $40 million of the funds that are coming out the 105. Human exploration has been working for no less than three years on an asteroid-type mission. So we are levering what we have been doing for years.

As Congressman Brooks mentioned, SLS and MPCV were made for the human exploration part of an asteroid mission. It gives us an opportunity to demonstrate that vehicle and its capability, Orion's capability to go beyond the Moon to deep space long before we have to make an 8-month mission to Mars and hoping that our people will survive in that.

Mr. STEWART. Well, and I think actually, General, you bring up my point, and this is actually my primary question. If your ultimate objective is to go to Mars and knowing that there are building blocks that are required to do that, technological building blocks along the way that you have to accomplish in order to do that, does a lunar mission or the asteroid retrieval, does either of those give you a more significant foundation to build on, if that is your objective?

General BOLDEN. You asked the question a little bit differently than was asked earlier, and I thought about it. The Chairman told me to think about it again and come out and say forget about the asteroid mission. I am not ready to do that yet.

There is a decided advantage in an asteroid retrieval mission on the road to Mars. Solar electric propulsion is something we have got to have for deep space exploration. People have heard us say we are looking for game-changing propulsion. Solar electric propulsion has been around for a while but not the way we want to use it. There are varieties—you know, solar electric propulsion is a big name for a lot of different things you can do, hall thrusters, ion thrusters, VASIMR. That is one thing. Life support systems in the Orion module, I don't need to change the—I can take the existing system in the first Orion and go to the Moon. So there is no technological advantage here.

If I want to push technology, I want to go to deep space. I want to go somewhere where it is really, really, really challenging, and if we don't get it right, we are going to lose people.

Mr. STEWART. I appreciate that.

General BOLDEN. And let me tell you——

Mr. STEWART. Then if I could in the minute or so that I have left, you have given some great examples of technologies which are developed with this mission. Are there any technologies that we sacrifice or that we would develop with another lunar mission that would not be developed in——

General BOLDEN. It is not a matter of sacrificing technologies. It is a matter of requiring no new technology. We must remember, this is the greatest Nation in the world in terms of exploration of the universe. We have been to the Moon six times. We know how to do that.

Now, Dr. Gilruth, who most of you don't know, once said at the end of the Apollo program people will realize how difficult it was to go to the Moon when we try to return. So just because we went once doesn't mean it is going to be easy the next time.

I don't need any new technology to go to the Moon. I need money to go to the Moon. It is expensive to go into a gravity well of the lunar surface. I need new technologies to go to an asteroid in deep space or in a stable orbit rendezvous point around the Moon. And we have already started investing in that technology, and the minimal amounts of money—somebody asked why are we putting more money into technology development? Because we need it to fill the gaps. We have a technological roadmap that was certified by the National Research Council.

This is not an overnight thing. We didn't just think of this. You know, I have to correct Members of the Committee who have said several times it seems like we just thought this up. NASA has been working on this for decades. The President focused us like a laser when he stood up at the Kennedy Space Center. And people don't relate it, and I am not trying to relate it to John Kennedy, but there were people who thought the President lost his mind when he stood in Rice University campus and said within this decade we are sending humans to the Moon and bringing them safely back.

Gene Kranz who is a role model of mine and a flight director from— he is Mr. Failure-is-not-an-Option. He said he went home. He said he thought the President had lost his mind. He woke up the next morning and he said no, that is not the case. The President trusts us, and he thinks we can do this.

To have the President of the United States go to Florida and say NASA is going to send somebody to an asteroid in 2025 and to Mars in 2030, I couldn't be more proud.

Mr. STEWART. And my time is up. Thank you, General. I appreciate it. Mr. Chairman?

Chairman PALAZZO. I now recognize Ms. Bonamici for five minutes.

Ms. BONAMICI. Thank you very much, Mr. Chairman. Thank you, General Bolden, for returning and for your service to our Nation.

In a previous hearing in this Committee I pointed out some of the work that NASA does that affects Oregon's first district in several important ways from education opportunities, through the

Space Grant program, to whale monitoring activities through NASA's National Ocean Partnership. And I wanted to ask you about the weather and climate monitoring. The marine economy in Oregon is very important to the coastal areas, and they rely on the data provided by NOAA and NASA. And in this NASA budget, I see that the Joint Polar Satellite System two climate sensors are being transferred from NOAA to NASA. But there doesn't appear to be an accompanying increase in NASA's Earth Science budget. So I wanted to ask you if you could please elaborate on how NASA is going to carry out this new responsibility. What are the criteria for having NASA assume responsibility because we want to ensure that there are long-term measurements and observations that are sustained.

General BOLDEN. Congresswoman, I will take it for the record to get the exact amount, but I think we did get a modicum of funding that came with the climate sensors. But I will take that for the record. But I will say just as we did with the DSCOVR mission and others, we asked. We actually came to the House Appropriations Committee and said look, we would like to take this on because we think this is very important. In the case of DSCOVR, we have instruments that have already been built. They are already installed on the satellite. It makes no sense to us to take them off and put NASA's simulators on. And Chairman Wu said, look. I don't want to do that, but give it your best shot. You know, send me a proposal, and tell me what you are going to do.

And we demonstrated to him how doing it a different way we could bring it in at a much less cost than it had originally been proposed. And that is what we have become accustomed to doing.

Somebody mentioned earlier the fact that many of our missions have come in on budget or under budget and on schedule recently, and it was attributed to an increase in budget. That is not the case. I attribute it to the incredible people I have who are working for NASA who now have had a change of culture, if you will. They understand that we are not going to get any more money. And so they are looking for innovative ways to do things. We knew we couldn't get enough money for a classic asteroid mission, you know. That would be great if we could put humans on a big rocket and send them to an asteroid between Mars and Jupiter. Our budget is not going to allow that. Never, ever. I doubt it, unless we really do something big and you all decide to be generous.

So we had to innovate, and we came up with the concept that is now the hallmark of an asteroid retrieval mission. So that is the way we do things.

Ms. BONAMICI. Thank you. I had a great conversation with members of the American Institute of Aeronautics and Astronautics. They were in town to talk about research funding which is of course very important. We talked about the biological and physical science research that is done at the Space Station. As you know, there has been a lot of research in space that affects medical care here, and I wondered, because of the potential for key medical advancements, is it surprising that what seems like a relatively small amount of the funding for ISS goes to research functions. So will you elaborate on that a bit?

General BOLDEN. I think we have priced it about right, the amount of money that we put in our human research program, and I think what you are looking at is HRP that is dedicated to astronaut health and safety. What is not seen in that number is the amount of money that goes into human research. For example, the National Institutes of Health has a grant program in the millions of dollars, and the grantees do work on the International Space Station. One stipulation, can't have anything to do with astronauts. It has got to impact life here on Earth. Now, if it happens to help astronauts, great. But we don't count that kind of money that is being spent. CASIS, which is now the non-governmental organization that is responsible for going out and recruiting, selecting and then overseeing science experiments flown in the American segment of the International Space Station. Our utilization of the Space Station is up. The number of experiments that astronauts are able to do now that construction is over is up. It is a dynamic laboratory, better than anything everybody has ever seen before.

Ms. BONAMICI. Terrific. I will see if I can get one more question in. I understand that there is some work being done to develop a prototype exploration suit for use on board the ISS, and I wondered, is that a repurposing of the current, I guess it is the EMU that is used——

General BOLDEN. EMU?

Ms. BONAMICI. —or is it going to be replaced and will there be a competitive process for that?

General BOLDEN. My understanding is it will replace the EMU. It is a suit that is made to operate in a less than 1G environment of Mars. Looks like Buzz Lightyear, the one I have seen. You know, it is much less cumbersome, much less hard on the shoulder joints, for example, where we actually have had injuries with astronauts in the current EMU. So it is a new development.

Ms. BONAMICI. Did you have a competitive process for that?

General BOLDEN. It was chosen, it will be chosen, through a competitive process, yes.

Ms. BONAMICI. Thank you. Thank you very much. My time is expired. Thank you, Mr. Chairman.

General BOLDEN. I am sorry.

Ms. BONAMICI. Thank you.

Chairman PALAZZO. I now recognize Mr. Posey for five minutes.

Mr. POSEY. Thank you, Mr. Chairman, and I thank the general for joining us again. I have said it before and I will say it again, of all the agency heads that I have had the privilege to sit in, you have been the one that has been the most forthcoming and straight talking, and I appreciate that. Thank you.

I don't want to get redundant. I just want to get these things in a proper perspective, just kind of for my memory bank here. The Keck study suggested that an asteroid mission would cost $2.6 billion, and I understand NASA disagrees with that number. And I was just wondering how much NASA thinks it will cost to retrieve and return an asteroid or move it, whatever the goal ends up being?

General BOLDEN. Congressman Posey, I will correct you and say we don't disagree with the Keck number. However, our mission, as we envision it, is different from what the Keck number on which

it was based. Keck, very respected group of scientists who studied this, they did not have an SLS or an MPCV. They did not have a head start on solar electric propulsion. They assume that we were going to use a big rocket and go between, I think, between Mars and Jupiter into the asteroid belt to put humans with an asteroid. And so I think that is where the $2.6 billion came from. I have been cautioned by many, and so I will take their advice and not try to give you a number right now. We are going into mission formulation this summer. After we talk with our international partners, with academia, with amateurs to be quite honest, to find out what this mission should have in it, and then we will come back with a more definitive number on what we think it is going to cost. But my guess would be for a similar mission that Keck had, it will be something less than their estimate.

Mr. POSEY. Well, that is something because certainly when you talk to people about appropriations, they want to know what is at the end of the line. You know, if it costs this much to go to an asteroid or twice as much as going to the Moon, I mean, that makes sense and you can understand that.

How would you compare the cost of the Administration's lasso mission with a return to the Moon?

General BOLDEN. If I can use the example of the Keck study, and I am not adopting that but it is an example. An example is Keck said $2.6 billion to carry out their type of asteroid mission which we think is more expensive than ours. The numbers quoted to me for Altair, for the lander, for a human lunar exhibition or landing, $8 to $10 billion.

So going back to the Moon, if we use the numbers quoted for Altair which came from NASA in the Constellation program, and we use, we accept the numbers from Keck, then going to the Moon is almost a factor of three more expensive. And our budget won't sustain that, won't accommodate that.

Mr. POSEY. Yeah, and I heard that number when Congressman Stewart and you were having dialogue. Now, what is that number based on?

General BOLDEN. The Keck number or the Altair number?

Mr. POSEY. The return to the Moon number.

General BOLDEN. Return to the Moon? It is the number that I have been—I wasn't around, so I can't tell you. But I was quoted $8 to $10 billion for the lunar lander that was planned for the Constellation program. And one of the reasons that it never materialized was because NASA at the time did not have the funding.

Mr. POSEY. Yeah. Can you get us a copy of that, just that document just so we will have it?

General BOLDEN. We can do that.

Mr. POSEY. Because I hadn't seen it before.

General BOLDEN. We will do it.

Mr. POSEY. You know, could the hardware obviously that is being developed such as the SLS be used for both missions? I mean, wouldn't we use the same rocket to go to the asteroid that we would to the Moon?

General BOLDEN. If we are going anywhere in deep space, and I will stipulate that we can call the Moon deep space, but we don't consider the Moon deep space anymore. But you could use SLS to

go to the Moon. You will use SLS to go to an asteroid, to Mars and the like.

Mr. POSEY. Okay. The next thing of course I was going to ask if there is anything salvageable from the $9 billion Constellation mission to nowhere.

General BOLDEN. We are using Orion quite effectively. We have gotten its cost down, its weight down and it is on schedule to fly in 2014.

Mr. POSEY. Okay. Because I think that might offset some costs if we got some stuff in the ground or——

General BOLDEN. And to be fair, we flew Ares 1–X which was a part of the Constellation program. That was the last thing we did in the Constellation program. Ares 1–X was the most heavily instrumented rocket to ever go in space, and the data that we collected from Ares 1–X is now available to every rocket manufacturer in the country plus any rocket manufacturer that is cleared to receive ITAR related data I think.

Mr. POSEY. When Kennedy set the goal of going to the Moon within a decade, he literally inspired a Nation. You might have known a skeptic, but you know, as a teenager, it inspired me and my entire generation. When we heard the idea of going to an asteroid and maybe doing two space walks on asteroids, all I heard was crickets. So you know, what do you think the difference——

General BOLDEN. What is the difference?

Mr. POSEY. Yeah.

General BOLDEN. We are not at war. I was not marching in the streets of Columbia, South Carolina, as we were when President Kennedy announced we were going to the Moon. We were in the midst of the Civil Rights Era. You know, there was hatred being spewed all over the streets of the United States. We were at war in another country, and we were racing the Russians, the Soviets back then. We are not racing the Soviets. We have no—hopefully we will not have an enemy like we had then. Hopefully we will not go back into the streets in racial discord again, although I can't guarantee that sometimes. And definitely, you know, this Nation will be very cautious before it enters into another war like Vietnam or some others that people could cite. Significant difference in time and conditions.

Mr. POSEY. Thank you. I see my time has expired. Thank you.

Chairman PALAZZO. I now recognize Ms. Brownley for five minutes.

Ms. BROWNLEY. Thank you, Mr. Chair, and thank you, General Bolden, for your courageous service to our country. I really do appreciate it very much.

I have some questions about the budget request for construction and environmental compliance and restoration, specifically I am very interested in the budget request for cleanup of the Santa Susana Field Lab. This has been affecting my district for decades. NASA's original Fiscal Year 2013 request included $5.5 million for the Santa Susana Field Laboratory cleanup, and I understand that the Administration has not yet released its Fiscal Year 2013 spending plan and that the appropriations law enacted March 26 gives NASA 45 days to do so.

So a couple of questions here. Will NASA allocate the $15.5 million request in 2013 to the Santa Susana Field Lab cleanup and what activities does NASA intend to complete with those funds? And then further, will NASA's 2014 request of $20.6 million for the cleanup keep the project on schedule for completion by 2017? And what activities does NASA expect to complete with the 2014 year funds? And if Congress does not provide NASA with the full amount requested for 2014, how would the impact of NASA's ability to stay on track for cleanup completion in 2013?

General BOLDEN. Congresswoman, you know, I am as dedicated as anyone to making sure that this planet is as good as it can be and that life here is good. As far as I know, and I will get back to you for the record, we have not made any proposal for a change in the funding dedicated to Santa Susana. The last time I talked to the folk in the office responsible for that we were on target for completion of the cleanup by 2017, and that is what we intend to do.

Ms. BROWNLEY. Thank you very much.

General BOLDEN. Yes.

Ms. BROWNLEY. I would love it if at any time you were available to come visit the site and see it for yourself.

General BOLDEN. I would be glad to come.

Ms. BROWNLEY. Thank you.

Chairman PALAZZO. I want to thank the Administrator for his valuable testimony and the Members for their questions. The Members of the Committee may have additional questions. It has already been expressed to me that they will, so 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. Thank you.

[Whereupon, at 3:52 p.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Hon. Charles F. Bolden

National Aeronautics and Space Administration
Headquarters
Washington, DC 20546-0001

October 28, 2013

Reply to Attn of: OLIA/2013-00340/341f:MDC

The Honorable Steven Palazzo
Chairman
Subcommittee on Space and Aeronautics
Committee on Science, Space and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Palazzo:

Enclosed are the responses to written questions submitted by you, Representatives Edwards, Rohrabacher and Posey resulting from the April 24, 2013 hearing, titled "*An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014.*" This material completes the information requesting during this hearing.

Sincerely,

Seth Statler

L. Seth Statler
Associate Administrator
for Legislative and Intergovernmental Affairs

Enclosures

cc:
Rep. Donna Edwards

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
"An Overview of the National Aeronautics and Space Administration
Budget for Fiscal Year 2014"
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:

You stated that NASA has been working on the asteroid retrieval mission for several years. However, you also said that NASA won't have a cost estimate until at least this summer, and the only estimate thus far is $2.7B from the Keck Institute for Space Sciences. Where does NASA propose paying for this mission in its five-year budget plan? In a flat budget, how do you propose to pay for this asteroid retrieval mission going forward? What other projects might be sacrificed to pay for this mission?

ANSWER 1:

NASA's strategy for an asteroid redirect mission is to leverage ongoing activities, which individually provide technology advancements or new capabilities for human exploration, science and commercial applications that provide a stepping-stone for missions to Mars. Funding provided within the President's FY 2014 budget request will augment our existing activities in Space Technology, Science, and Human Exploration and Operations to: enhance our near-Earth asteroid detection and characterization assets; accelerate advanced solar electric propulsion development; and capture and maneuver of non-cooperative targets in space. The capability developments in FY 2014 are important in their own right independent of the proposed asteroid strategy.

Continued progress on the mission is conditional upon identification of a technically and programmatically feasible concept. NASA anticipates completing this summer an internal review of the redirection mission to assess technical and programmatic aspects of the mission. Budgetary findings of this review will be integrated into budget planning for FY 2015 with other priorities. We will keep the Committee apprised of progress.

QUESTION 2:

A report issued last December by the National Academy of Sciences about NASA's strategic direction 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." Why is this mission any different?

ANSWER 2:

NASA spent significant time examining the potential for sending astronauts directly to a near-Earth asteroid (NEA). Conducting a direct mission to one of the NEA targets identified to date would require greater than six-month round trip times. Such a mission would require the development of additional exploration assets/capabilities such as a deep space habitat; space exploration vehicle, including an airlock, and power and propulsion; long-duration cryogenic storage; more reliable life support systems; and a strategy for radiation protection.

The Asteroid Redirect Mission is another approach consistent with utilizing human spaceflight capabilities currently under development in important ways during early operations in the early 2020s. Astrodynamically stable regions in the lunar vicinity offer locales for early operations outside the Earth's gravity well. Interactions with an asteroid in this region will allow NASA to test and gain operational experience in proximity operations and rendezvous with a non-cooperative target, astronaut experience in complex extra vehicular activity (EVA), and sample collection, handling and return. In addition, these locales offer an ideal venue for initial crewed operations in regions in which returns to Earth are impossible for many days. This will stretch our human spaceflight capabilities in a safer approach than very long journeys of many months to a year. This allows NASA to gain experience in practicing aborts and contingency procedures needed for operations outside the Earth's gravity well, and handling maintenance and repair, including with EVAs.

These activities will keep the United States in the forefront of peaceful uses of outer space, complement scientific investigations and technology demonstrations on the International Space Station (ISS), and provide valuable experience in mission planning and operations to prepare and reduce risk for future crewed deep-space missions, such as a future human mission to Mars.

We envision an important role for international participation in all aspects of the asteroid initiative. A partnership with NASA on the Asteroid Redirect Mission would be an opportunity for the international community to contribute to a unique and historic mission and one that builds upon our long experience of international cooperation, such as those in the ISS Program or missions such as the Curiosity Rover on Mars.

QUESTION 3:

NASA's Small Bodies Advisory Group also commented on the potential asteroid mission, stating, " [w]hile the participants found it to be very interesting and entertaining, it was not considered to be a serious proposal because of obvious challenges, including the practical difficulty of identifying a target in an appropriate orbit with the necessary physical characteristics within the required lead time using existing or near- to long-term ground-based or space-based survey assets." Why did NASA find this mission compelling when its advisory body did not? Does NASA value the SBAG's advice or is there another reason they were ignored?

ANSWER 3:

NASA continues to work with the Small Bodies Assessment Group (SBAG) and values their support and advice. The SBAG only provides science input for planning and prioritizing human and robotic exploration activities for the small bodies of the Solar System. With regard to the Asteroid Redirect Mission (ARM), NASA finds this mission compelling from numerous perspectives including science, technology and human exploration.

While the ARM planning is not driven by science objectives, the necessary search for a suitable target asteroid would provide an increase in the discovery rate of NEOs along with a simultaneous increase in the characterization of this population. Since the stringent requirements for a suitable ARM target body dictate that these targets be in rather Earth-like orbits, this population of Earth's closest celestial neighbors would be better characterized than is currently the case. Those NEOs that are most easily reached by spacecraft, or most suitable for round trip human exploration, are the same objects that represent the greatest likelihood of striking Earth. A better understanding of this population would benefit both planetary science and planetary defense. Because of their modest gravity fields, round trip missions to the surfaces of many NEOs require less energy than round trip missions to the Moon's surface. Many of these NEOs are far richer than the Moon in valuable minerals, metals and the hydrated minerals that can provide water resources. In turn, the extracted water can be broken down into hydrogen and oxygen - the most efficient form of rocket fuel. For the future human exploration of the inner solar system, these NEOs could provide the raw materials for space habitats as well as provide the watering holes and fueling stations for future interplanetary travel. NASA's strategic study of near-Earth asteroids is well placed.

QUESTION 4:

There have been many in the scientific community and spaceflight communities, as well as Members of Congress, that have questioned the efficacy of the asteroid retrieval mission, including the Small Bodies Assessment Group which NASA set up to offer technical and program management advice for just these types of missions. Can you explain why NASA did not request their assistance in formulating this mission?

ANSWER 4:

NASA selected an integrated strategy to leverage ongoing Space Technology, Science, and Human Exploration and Operations activities to meet the President's challenge to send astronauts to an asteroid by 2025, with a long-term goal of international partnership to implement a collaborative path to future Mars missions. The Small Bodies Assessment Group (SBAG) provides science input for planning and prioritizing human and robotic exploration activities for the small bodies of the Solar System. NASA has not selected a mission concept to implement this strategy and has already begun to engage the scientific and spaceflight communities in this discussion.

The SBAG held a meeting in late July 2013 where they discussed several topics, including the asteroid redirect mission. While the SBAG recognizes that ARM has not been defined as a science mission, the committee does find "great value in enhancing NASA's capabilities in small body discovery and characterization" and that "the enhancement to NEO discovery and characterization efforts proposed as part of the Asteroid Initiative would be greater still if it were to be continued for more than one year." The SBAG committee also found that the "formation of an independent Mission Definition Team (MDT) prior to commitment of significant resources and mission confirmation would allow for community participation in the relevant fields for the mission (including small body science) and provide a non-advocate peer review of the expected benefit if mission success criteria are met." As we proceed with the asteroid mission formulation, the SBAG will continue to be a critical part of this planning process.

For reference, the full list of the July 2013 SBAG meeting findings can be found at http://www.lpi.usra.edu/sbag/.

QUESTION 5:

Japan already conducted an asteroid return mission with the Hayabusa mission and is developing a follow-on mission that will return asteroid samples in 2020. Also, NASA is already developing the OSIRIS-Rex mission to return an asteroid sample in 2023. From a scientific standpoint, what does NASA plan to accomplish with this mission that was not or will not be accomplished by these missions? From an exploration architecture standpoint, what will we learn from this mission that we couldn't by focusing on a lunar mission? Please provide any trade-studies that informed this assessment.

ANSWER 5:

While the OSIRIS-REx and Hayabusa missions were driven by science objectives, ARM planning brings together the best of NASA's science, technology and human exploration efforts to achieve this great technological feat. Crewed rendezvous with and exploration of the redirected asteroid will occur in the lunar vicinity. This mission prepares us for future long duration deep space missions, but also exploits the near term learning opportunities in near lunar space. Astrodynamically stable regions in the lunar vicinity offer locales for early operations in the deep space environment. Lunar distant retrograde orbits offer an ideal venue for initial crewed operations in regions in which returns to Earth are impossible for many days. Interactions with an asteroid in this region will allow NASA to test and gain operational experience in proximity operations and rendezvous with a non-cooperative target, astronaut experience in complex extra vehicular activity (EVA), and sample collection, handling and return. This also provides NASA valuable experience practicing aborts and contingency procedures needed for operations outside the Earth's gravity well, and handling maintenance and repair, including with EVAs. This mission is a step in a Flexible Path approach, a steadily advancing, measured, and publicly notable human exploration of space beyond Earth

orbit that would build our capability to explore, enable scientific and economic return, and engage the public[1]. NASA will take steps toward Mars, learning to live and work in free-space and near planets; under the conditions humans will meet on the way toward Mars[1]. Augustine et al recommended in a strategy summary, that "...Before we explore Mars, we will likely do some of both the Flexible Path and lunar exploration — the primary decision *is one of sequence*. This will be largely guided by budgetary, programmatic, and program sustainability considerations[1]."

The benefits to science include the availability of large quantities (many tens of kg) of asteroidal samples selected in real time by astronauts. There are a variety of types of primitive solar system objects that each provide part of the story of solar system origins, and the one selected is likely to be different from that targeted by OSIRIS-REx. In addition, the scientific study of asteroids will benefit directly from the doubling of the Near Earth Object observation program budget requested in FY 2014. The planned enhancements in the search for Near Earth Objects will yield an increase in the discovery rate and characterization of the NEO population, as well as increased discoveries of potential ARM targets. In fact, a better understanding of this population would benefit both planetary science and planetary defense.

[1] Austine N., et al, "Seeking a Human Space Flight Program Worthy of a Great Nation," March 2010.

QUESTION 6:

The likelihood of finding a small asteroid of the size, orbit, and composition necessary for a retrieval mission is very low, yet NASA seems quite convinced it could be done in time for one of the first crewed SLS missions. What is the basis for this confidence? How many candidate asteroids have you identified and ruled out thus far? How many candidate asteroids are still left to be evaluated? At what rate are you identifying candidate asteroids?

ANSWER 6:

At this time, several 10-meter class asteroids that may be viable candidates for the Asteroid Redirect Mission (ARM) have been found through NASA's Near Earth Object Observation (NEOO) Program, at an average rate of 2 to 3 per year. This discovery rate will not decrease and NASA is working to increase it with enhancements to existing surveys, many of which are already in process and funded by the NEOO Program, or with new surveys that can come online in the next few years. These enhancements combined with the knowledge that there are four additional years to accumulate candidate target discoveries provides the basis of confidence that NASA will be able to identify a suitable asteroid for ARM. The total number of NEAs in the population viable for ARM candidates could be over 3,000. We have already found 216 ten-meter sized NEAs, 13 of which are possible candidates for assessment against the ARM criteria, although only 5 are available in the time period when we desire to conduct the mission.

In addition, NASA is studying an alternative approach that could include capturing one or more boulders from a larger near-Earth asteroid and transporting those boulder(s) to the vicinity of the Moon in the 2020-2025 timeframe. Under this approach, NASA would target an approximately 100+ meter asteroid, which is generally easier to detect than very small asteroids, and capture one or more boulders measuring 1-10 meters across. This larger target asteroid could allow NASA to demonstrate planetary defense techniques by measurably altering its trajectory. The study team is assessing various options for planetary defense demonstrations and the delivery of other payloads under this approach.

QUESTION 7:

Part of the budget request this year includes an additional $20M for the Near Earth Object Observations program. This money is supposed to be used for additional telescope time for detection of candidate asteroids for a retrieval mission.

a. What are the metrics that you will use to hold the program accountable for this additional funding?

b. How often do you plan to publish the ongoing results of NASA's efforts with this new funding?

c. Will surveying for 7-10 meter asteroids have any application for planetary defense if NEOs of that size will burn up in the atmosphere?

ANSWER 7:

NASA's Near Earth Object Observation (NEOO) program has established metrics and an automatic update process for all NEOs that will continue to be utilized to publish ongoing results. The metrics collected include data such as orbital path, size, shape, mass, composition and structure of these objects as well as the accumulated percentage and total number of discovered NEOs. As new data become available for a particular NEO, its orbit and relevant information are automatically updated and displayed on the NEO program website (http://neo.jpl.nasa.gov) for communication across the scientific community and public.

As noted in the response to Question 3, the necessary search for a suitable target asteroid would provide a significant increase in the discovery rate of all sizes of NEOs along with a simultaneous increase in the characterization of this population. It will use current and emerging capabilities to help detect both medium to large asteroids that pose a hazard to Earth as well as small asteroids that could be candidates for the initiative. Therefore, this better understanding of this population would benefit both planetary science and planetary defense.

QUESTION 8:

You have repeatedly said that without the requested amount for the Commercial Crew

program, the timeline for crewed flights would slip and routine flights to station will not start in 2017 as planned. How many providers are you assuming when making that statement? Could we maintain the 2017 milestone within that $500M ceiling by carrying fewer partners or an alternative development strategy?

ANSWER 8:

The Agency does not believe the 2017 milestone could be maintained at $500M per year under any scenario. With $821M in FY 2014, the Commercial Crew Program (CCP) can stay on track and meet the program objectives. The basic strategy is to facilitate the development of more than one provider, which can be accomplished under certain assumptions (i.e., cost-share, design risks, etc.), largely because time and again competition has proven an effective means of keeping costs down. Having multiple companies competing against each other will help ensure the safest and most cost effective systems possible for the Government. The Phase 2 Certification proposals will enable NASA to make the most informed decision regarding the number of providers.

QUESTION 9:

What is stopping NASA from investing in a single commercial crew carrier and ensuring that partner will be ready and able to service the space station as soon as is practically and safely possible?

ANSWER 9:

Maintaining competition for the Commercial Crew Program is critical to ensuring that NASA and the Nation receive the best value for future U.S.-based crew transportation to ISS. In addition, continued competition incentivizes companies to expand their commercial customer bases by selling services to others or to take advantage of opportunities for efficiencies to support reasonable prices. Continued competition also incentivizes the companies to invest their own funds and share in the development costs of their crew transportation system. Competition is the fundamental basis for establishing fair and reasonable pricing for all requirements. Having industry share in the cost of development and selling seats to other customers in addition to NASA will likely decrease NASA's costs for crew transportation services in both the short and long-term.

The Agency also believes the competitive environment provides strong incentives for the companies to make the investments needed to align their commercial offerings with NASA's certification requirements in order to remain competitive in the future certification and services phases. Having multiple companies competing against each other will help ensure the safest and most cost effective systems possible for the Government.

QUESTION 10:

Once the commercial crew development program has ended and NASA is ready to request formal bids for crew transportation, what would happen in the event that the Russian government underbids American companies? Would NASA be willing give the contract to the Russians in this scenario?

ANSWER 10:

NASA is committed to procuring crew transportation and rescue services from one or more domestic, commercial providers.

QUESTION 11:

What do you see as the future of the commercial crew spaceflight program after the de-orbiting of the International Space Station?

ANSWER 11:

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 12:

NASA recently signed an unfunded Space Act Agreement with Bigelow Aerospace to study the potential for expansion of commercial uses for a lunar base and outposts beyond low Earth orbit.

a. Does NASA believe there is a commercial market beyond low Earth orbit?
b. Why would NASA encourage commercial entities to explore the use of a lunar base when NASA sees no value in such a base for the U.S. Government?
c. Would NASA plan to lease a commercial outpost or lunar base for research if it was available?

ANSWER 12:

The Space Act states that the "general welfare of the United States requires that the Administration seek and encourage, to the maximum extent possible, the fullest commercial use of space." In March 2013, NASA signed a Space Act Agreement (SAA) with Bigelow Aerospace to study possible commercial applications for beyond-low-Earth-orbit (beyond-LEO) human spaceflight activities. In the future, there may be

opportunities for joint Government-commercial activities beyond LEO, and the study, which is being done in two parts, is intended to survey current beyond low Earth orbit private sector spaceflight-related goals and objectives and then outline specific potential assets/capabilities in the private sector. The study is not specifically focused on, or limited to, a lunar facility.

Specifically the two deliverables/gates are defined as:

Gate 1: Conduct a joint formulation of objectives for the commercial and government contributions and utilization for the development and exploration of space beyond low Earth orbit.

Gate 2: Assess the intersection of the capability to live and work in low Earth orbit with other commercial interests in low Earth orbit and all of cislunar space, including specific commercial proposals and interests towards those ends.

QUESTION 13:

How much of 21st Century Launch Capability Complex funding is for unique Commercial Provider requirements rather than SLS requirements? How much is unique to SLS? How much is dual-use?

ANSWER 13:

The FY 2012 appropriations conference report stipulated that 21st Century Space Launch Complex (21CSLC) funds are to be available for ground operations and infrastructure that support multi-user program activities. NASA's guiding principle for Exploration Ground Systems (EGS) development to support the Space Launch System (SLS) and Orion is not to *preclude* multi-use whenever possible, but EGS activities are conducted in support of NASA's Exploration systems. Similarly, 21st CSLC is focused on infrastructure that supports multiple users (commercial, defense, and national security); none of 21st CSLC is unique to SLS. However, benefits can be extensible to SLS and Orion as a user of the generic infrastructure at KSC. In 2013, funding for EGS was $355.1M and funding for 21CSLC was $39.0 M (these figures do not include CoF funding).

QUESTION 14:

For the third year in a row, NASA submitted a budget request that reduces funding for the Orion crew capsule. The Administration's budget request for NASA this year cuts congressionally required funding for Orion by $200M.

a. Are there deadlines or requirements that will be challenging to meet without these funds?

ANSWER 14a:

The FY 2014 President's Budget request, balancing the Nation's goals for space exploration with the current fiscal climate, provides the necessary funding profile required to keep SLS, Orion, and EGS moving forward to achieve EFT-1 in 2014, EM-1 in 2017, and EM-2 in 2021.

QUESTION 14b:

If not, how did NASA manage to lower necessary costs for this project; and how could these strategies be applied to successfully lower costs for other project within NASA?

ANSWER 14b:

The FY 2014 President's Budget request for Orion did not lower the costs for the project. The FY 2014 request was essentially flat with the 2013 Request. The apparent reduction is because Congress added funding above the request in 2013. The budget balances the Nation's goals for space exploration with the current fiscal climate, and provides the necessary funding profile required to keep SLS, Orion, and EGS moving forward to achieve EFT-1 in 2014, EM-1 in 2017, and EM-2 in 2021.

QUESTION 14c:

Are you still planning the Orion crew capsule to act as a back-up for NASA's commercial crew vehicles and Russian [capabilities]?

ANSWER 14c:

NASA anticipates that commercial crew transportation services to ISS will be available in 2017. If this is not the case, and if Russian Soyuz services are also unavailable, NASA could potentially move the 2021 date of the 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.

QUESTION 14d:

How much would it cost for this capability?

ANSWER 14d:

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, Exploration Mission-2 to 2018, 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 15:

NASA plans to launch a test of the Orion in 2014. How can you ensure this test will occur on time if you continue asking for reductions in funding for the program?

ANSWER 15:

The FY 2014 request for Orion was essentially flat with the 2013 Request. Any apparent reduction is because Congress added funding above the request in 2013. Please see response to Question 14a, above, regarding the phasing of Orion, SLS, and EGS to maintain key launch dates, including the 2014 date for EFT-1.

QUESTION 16:

Under current top-line funding levels, what is the cost-schedule confidence level for Orion being operational by 2017? How much additional money is needed to raise that level to 65% and 70%?

ANSWER 16:

Cost and schedule confidence level commitments (which will include impacts associated with different confidence levels) will be provided as part of the Key Decision Point "C" (KDP-C), which is scheduled for the first quarter of FY 2015.

QUESTION 17:

The Orion Ascent Abort test has slipped from 2015 to 2018. Is this a result of the planned cuts in this year's budget request?

ANSWER 17:

The FY 2014 request for Orion was essentially flat with the 2013 Request. Any apparent reduction is because Congress added funding above the request in 2013. The Agency is rephasing the Orion altitude abort test, now slated for 2018, to better fit the overall development profile of its exploration systems, but that will not impact the established flight dates for exploration missions

QUESTION 18:

Is Orion dependent on European development of a service module?

a. If so, are we putting a foreign partner on the critical path of an agency priority just as we did with the ISS and Russian participation?

ANSWER 18a:

NASA is depending on ESA to provide the Service Module (SM) for Exploration Mission 1 (EM-1) as a joint effort in which NASA is providing some equipment and parts to complete the SM. Current agreements call for ESA to provide spares from EM-1, which can be used to support EM-2.

QUESTION 18b:

If they cannot meet their obligations, as Russia failed to do, how will NASA pay for this shortfall?

ANSWER 18b:

ESA is responsible for meeting their obligations and commitments to support EM-1. This international agreement builds on NASA's existing strong cooperative relationship with ESA on the International Space Station (ISS) and other activities and expands the successful partnership to exploration activities beyond Earth orbit. NASA and ESA are closely collaborating on the technical design and schedule for the ESA SM, and believe that using an ATV-based design for the ESA SM has manageable risks.

QUESTION 19:

There seems to be some confusion about which programs are charged for which changes at the Kennedy Space Center in preparation for SLS and possible commercial users. Can you explain the distinction between work being done for Exploration Ground Systems and work being done for the 21st Century Launch Complex?

ANSWER 19:

Please see response to Question #13, above. NASA's guiding principle for Exploration Ground Systems (EGS) development to support the Space Launch System (SLS) and Orion is not to *preclude* multi-use whenever possible, but EGS activities are conducted in support of NASA's Exploration systems. Similarly, 21st CSLC is focused on infrastructure that supports multiple users (commercial, defense, and national security). However, benefits can be extensible to SLS and Orion as a user of the generic infrastructure at KSC.

QUESTION 20:

Under the current design, SLS will only be able to lift 70 tons to low earth orbit and 19 tons to beyond low earth orbit. In order to accomplish any meaningful exploration, this will have to be increased by developing an upper stage as advanced boosters will only provide additional capability (105 tons) to low earth orbit.

a. When will NASA begin development of the SLS upper stage?

ANSWER 20a:

NASA has in place a development plan to evolve SLS from the initial 70 metric ton lift capability to the 130 metric ton capability that will be required to undertake missions to Mars. Along this path is an evolutionary step that provides a 105 metric ton capability, enabled by either developing an Upper Stage or Advanced Boosters. NASA expects to refine the sequence of the evolution plan over the next year and, in the meantime, is performing risk reduction and commonality activities of both options. Both are required to achieve the 130 metric ton capability.

QUESTION 20b:

Is an upper stage needed for the proposed asteroid mission?

ANSWER 20b:

The SLS Upper Stage is not required for the proposed asteroid mission; all mission objectives can be achieved with the 70 metric ton capability.

QUESTION 20c:

How much money is NASA investing in the development of the Interim Cryogenic Propulsive Stage?

ANSWER 20c:

NASA is in the process of definitizing a contract with The Boeing Company for the modification and production of two ICPS units. NASA will notify the Congress of the value of that contract once it is definitized (which is planned to happen in the fourth quarter of CY 2013).

QUESTION 21:

The NASA Authorization Act of 2010 required NASA to build the SLS to a set of strict specifications including an eventual lift capability of 130 tons. Without this requirement, how would NASA develop the SLS?

ANSWER 21:

NASA has not studied how it would build an SLS if it didn't have the requirements in the 2010 Authorization Act.

QUESTION 22:

Has NASA conducted a review of research goals that would inform the needed

operational lifetime of the ISS?

ANSWER 22:

Yes, NASA is undertaking a review of research and technology goals that would inform the required operational lifetime of ISS. Since the research being conducted onboard the ISS has a broad spectrum of goals, the ISS Program will need to integrate these reviews of ISS research goals into a complete assessment of requirements for ISS operational lifetime. First, NASA is conducting research into human health and performance risks to enable long-duration spaceflight beyond low Earth orbit. The Human Research Program (HRP) uses the ISS to investigate and mitigate the highest risks to human health and performance, providing essential countermeasures and technologies for human space exploration. Risks include physiological effects from microgravity and radiation, as well as unique challenges in medical treatment, human factors, and behavioral health support. NASA is currently assessing the progress of our human research program toward its goals.

Technology development activities onboard the ISS are also driven by NASA's overall exploration goals to extend human presence beyond LEO. As a technology development and demonstration platform for exploration, the ISS is currently being utilized to demonstrate advances in life support systems, robotics for crew support and spacecraft servicing, and space durable materials. NASA is also funding technology development activities that will eventually be demonstrated onboard the ISS such as EVA systems, radiation monitoring, docking systems, and autonomous mission operations. A thorough assessment of all the research and technology development goals will be needed to inform the required ISS operational lifetime.

QUESTION 23:

The Commercial Resupply Contract signed by Orbital Sciences Corporation and Space Exploration Technologies will end in 2017. What is NASA's plan for cargo resupply to station after the end of those contracts?

ANSWER 23:

NASA would consider re-competing the contract, or modifying the existing contract to the extent authorized by procurement regulations.

QUESTION 24:

NOAA is cutting the climate sensors from the Joint Polar Satellite System Program (JPSS) in order to focus the program on its weather mission. NASA's budget request seeks to have NASA now pay for the development of these sensors.

a. Why is NASA paying for long term climate monitoring capabilities that NOAA decided were not a priority?

ANSWER 24a:

Sustained, long-term measurements of solar irradiance, vertical ozone profiles, and Earth radiation budget are important for a wide range of important NASA research studies such as, for example, temperature trending During the period in which these measurements were to be routinely acquired by NOAA as part of the nation's operational polar orbiting satellite system, it was highly cost-efficient for NASA to utilize those data in our research programs – just as some NASA research measurements, such as MODIS data on aerosols, dust and atmospheric dynamics in weather forecasting, QuikSCAT data and AIRS data, are utilized routinely by NOAA and DoD to improve the accuracy of weather forecasts. Although the Joint Polar Satellite System is now being focused on its key weather forecasting objectives, the overall importance of the solar irradiance, ozone profile, and Earth radiation budget data remains high for NASA's research activities and for the nation's understanding of the climate system; indeed, if these measurements are not continued in a sustained manner, significant NASA research investigations temperature trend studies, solar irradiance information from SORCE and ACRIMSAT, and time series information from TRMM, Aqua and Aura that is used routinely in modeling work - and all U.S. global change research will be negatively impacted. Therefore, NASA will develop approaches to efficiently acquire these measurements, which it will make available to all U.S. agencies as well as to the research and user communities.

QUESTION 24b:

What will NASA cut in order to accommodate these new requirements?

ANSWER 24b:

No other programs or projects have been cut specifically to fund the Climate Sensors. NASA continues to maintain a balanced portfolio of missions. The President's FY 2014 budget request balances risk, introduces selected refinements in implementation approaches, and capitalizes on efficiencies being realized across ongoing activities in the portfolio.

QUESTION 24c:

Why is NASA not conducting this work on a fully reimbursable basis through the Joint Agency Satellite Division?

ANSWER 24c:

The President's FY 2014 budget request appropriately provides NASA with the funds as well as the responsibilities for designing and implementing an architecture for sustained provision of the solar irradiance, ozone profile, and Earth radiation budget information important for NASA – and indeed national - science programs. Within the NASA Science Mission Directorate (SMD), the Joint Agency Satellite Division takes

responsibility only for those activities, which are implemented by NASA but are funded by other agencies. The Earth Science Division (ESD) has the responsibility for design, implementation, and exploitation of Earth-related missions that are funded by NASA. By conducting the architecture design and implementation of these measurements in ESD, the Nation will benefit from the largest potential solution set for achieving these measurements, and the maximum synergy by making use of the entire ESD portfolio of missions and techniques. The Administration has made the decision to pursue the work through ESD.

QUESTION 25:

It appears as though NASA is now responsible for the development of future land remote sensing capabilities- a responsibility that previously fell to the U.S. Geological Survey (USGS).

a. Why is NASA paying for other agency's requirements?

ANSWER 25a:

Since the early 1970s, NASA has designed, implemented, launched and completed the commissioning and on-orbit check-out of each of the individual Landsat missions that reached orbit. Landsat capabilities continue to be informed by USGS's in-depth knowledge of the users and uses of Landsat measurements. The Administration's plan continues the effective historical approach whereby NASA funds U.S. Government-supplied flight systems, and the USGS funds the processing, archiving and distribution of the information products from the land imaging system.

QUESTION 25b:

Why is NASA not conducting this work on a fully reimbursable basis through the Joint Agency Satellite Division?

ANSWER 25b:

The President's FY 2014 budget request appropriately provides NASA with the funds as well as the responsibilities for designing and implementing an architecture for sustained provision of global land imaging measurements consistent with the ongoing Landsat-7 and LDCM/Landsat-8 data products. These measurements and information products support a wide range of NASA Earth Science and applications investigations, in addition to aiding USGS and many other Federal and non-Federal agencies and organizations. Within the NASA Science Mission Directorate (SMD), the Joint Agency Satellite Division takes responsibility only for those activities, which are implemented by NASA but are funded by other agencies. The Earth Science Division takes responsibility for design, implementation, and exploitation of Earth-related missions that are funded by NASA. By conducting the architecture design and eventual implantation of the global land surface measurements in ESD, the Nation will benefit from the largest potential

solution set for the design for the acquisition system, and the maximum synergy with other related measurements, making use of the entire ESD portfolio of missions and techniques. The Administration has made the decision to pursue the work through ESD.

QUESTION 26:

The Deep Space Climate Observatory (DSCOVR) mission was reinstated to fulfill a space weather mission, not a climate mission; however NOAA sought to add the climate sensors EPIC and NISTAR back on the satellite last year. The Appropriators denied the request for NOAA to add the sensors, but allowed the funding to come from NASA.

a. Why is NASA paying for another agency's requirements?

ANSWER 26a:

The DSCOVR spacecraft was designed originally to carry the Earth Observation instruments. In the FY 2009 and FY 2010 budgets, Congress appropriated funds for NASA to refurbish and recalibrate the EPIC and NISTAR Earth Observation instruments, which NASA has done. Integration and flight of the Earth Observation instruments is the most cost-effective and expeditious way to provide Earth observation capability. Given NASA's in-depth knowledge of the refurbished Earth Observation instruments, NASA's development of a basic ground processing system for the instruments is the most cost-effective way to redeem the Nation's investment in these instruments, by allowing their measurements to be used to advance science.

QUESTION 26b:

Why is the Administration changing the purpose of the DSCOVR mission?

ANSWER 26b:

Presently, space weather information from the NASA ACE mission at the Earth-Sun Lagrange point ("L1") gives the Nation the earliest warning of extreme space weather events. From the start, the DSCOVR mission was designed to acquire a portion of the needed important space weather measurements to continue this data stream.

The DSCOVR spacecraft was designed originally to also carry the Earth Observation instruments. For technical engineering reasons, safe launch and operation of DSCOVR requires the mass and thermal properties of the EPIC and NISTAR Earth Observation instruments to be consistent with the spacecraft design. In the FY 2009 and FY 2010 budgets, Congress appropriated funds for NASA to refurbish and recalibrate the EPIC and NISTAR Earth Observation instruments, which NASA has done. Integration and flight of the Earth Observation instruments is thus the most cost-effective and expeditious way to provide Earth observation capability. Given NASA's in-depth knowledge of the refurbished Earth Observation instruments, NASA's development of a basic ground processing system for the instruments is the most cost-effective way to redeem the

nation's investment in these instruments, by allowing their measurements to be used to advance science.

QUESTION 26c:

Will EPIC and NISTAR data be used operationally, and if so, who will pay for that- NASA or NOAA?

ANSWER 26c:

The NASA objectives for EPIC and NISTAR data are focused entirely on advancing NASA Earth system science research and applications development and testing activities. NASA makes its Earth Science satellite data publically available to other Federal agencies, as well as state and local governments and researchers, for their modeling and operational needs.

QUESTION 26d:

Why is NASA not conducting this work on a fully reimbursable basis through the Joint Agency Satellite Division?

ANSWER 26d:

For the reasons previously discussed, NASA requested funding only for the DSCOVR Earth Observation instruments EPIC and NISTAR. These are secondary instruments on the DSCOVR mission — DSCOVR is primarily a space weather mission.

QUESTION 27:

Over the past 50 years, robotic planetary missions have opened up the solar system. Few programs are as visible, inspirational, or scientifically important as NASA's planetary program. Yet, the FY 2014 budget continues the disproportionate and deep cuts begun in FY 2012 and FY 2013. The FY 2013 request alone represented a 20% cut ($300M) to the program, and FY 2014 fundamentally continues that path, despite Congress' current objection to this path in the FY 2013 Appropriations bill. NASA's behavior seems to indicate a "going out of business" philosophy with few new missions slated for full-scale development, and eventual withdrawal.

a. Why has the planetary program been singled out for such significant budget cuts?

b. Do you believe that the U.S. should cede its leadership in solar system exploration? If not, what are you prepared to do to ensure that NASA implements a program consistent with the priorities in the decadal survey?

c. How will the proposed cuts to Planetary Science impact specific missions?

ANSWER 27:

The FY 2014 President's budget request includes a total budget for Planetary Science of $1,217.5M, which is about a 5 percent decline from the 2009 level. This request is part of a broader approach to maintain balance across NASA within a constrained fiscal environment, and to ensure that the request is consistent with available resources while still maintaining the highest priority science across the portfolio of Science programs. The FY14 request maintains a balanced suite of Discovery, New Frontiers, and strategic missions as recommended in the most recent decadal survey.

This budget funds enhanced surveys of near-Earth objects, commences development of the Mars 2020 mission based on Curiosity architecture, provides for instrument contributions to ESA's ExoMars rover and the JUICE flagship mission, and supports production of planetary exploration enabling Plutonium-238, in partnership with the Department of Energy. Additionally, the FY 2014 request continues to support planetary science technology development and research awards. This funding level continues funding for missions in development and those currently operating, though with reduced budgets for missions in extended operations, as determined by the Senior Review.

QUESTION 28:

Congress provided direction in the FY 2013 Appropriations bill to begin work on a mission to Jupiter's moon Europa - one of the most interesting destinations in the solar system with vast ice-covered oceans that could potentially support some forms of life. The bill provided $75M in FY 2013 for such a mission. What are NASA's plans to comply with this direction? When might a mission to Europa be launched?

ANSWER 28:

The FY 2013 Consolidated and Further Continuing Appropriations Act (P.L. 113-6) stipulates, "Provided That $75,000,000 shall be for pre-formulation and/or formulation activities for a mission that meets the science goals outlined for the Jupiter Europa mission in the most recent planetary science decadal survey." Given the harsh radiation environment around Europa, and our current understanding of the technologies needed to carry out this type of mission, NASA plans to use these FY 2013 funds for a variety of early activities related to a future mission to Europa, including:

- Initiating an instrument technology development program to reduce one of the key identified risks for a Europa mission;
- Studying design impacts to spacecraft and concept of operations (launch environment, Europa multiple flyby mission concept propulsion module) and the launch vehicle trade space;
- Studying and testing planetary protection sterilization procedures and their associated impacts to science instruments and spacecraft; and,
- Conducting preliminary design work on the proposed reconnaissance instrument(s).

The concept studies that NASA has performed over the last year have been narrowed down to one mission (called the Europa Clipper) that retains the minimum requirements delineated in the Planetary Decadal survey for the detailed study of Europa. Once these studies are complete and a budget profile for this mission has been identified, a possible launch date can be determined.

QUESTION 29:

Why is NASA choosing to move forward with an Asteroid Retrieval Mission- a mission of debatable merit- at a cost several billion dollars, while longstanding priorities of undeniable scientific value and comparable cost, such as a robotic Mars Sample Return or a mission to Jupiter's moon Europa, are passed over?

ANSWER 29:

The President's FY 2014 budget request continues to implement the bi-partisan strategy for space exploration approved by Congress in 2010, a plan that advances U.S. preeminence in science and technology, improves life on Earth, and protects our home planet, all while helping create jobs and strengthening the American economy. This budget reflects current fiscal realities by aligning and leveraging relevant portions of NASA's Space Technology, Science, and Human Exploration and Operations capabilities to achieve the President's challenge of sending astronauts to an asteroid by 2025.

The overall mission is composed of three separate and independently compelling elements: the detection and characterization of candidate near-Earth asteroids; the robotic rendezvous, capture, and redirection of a target asteroid to the Earth-Moon system; and the crewed mission to explore and sample the captured asteroid using the Space Launch System (SLS) and the Orion crew capsule. This mission represents an unprecedented technological challenge -- raising the bar for human exploration and discovery, while helping protect our home planet and bringing us closer to a human mission to Mars in the 2030s. Each mission element will heavily leverage on-going activities in Space Technology, Science, and Human Exploration and Operations.

QUESTION 30:

Please provide details on the new Mars Robotic Mission planned for 2020. Will this mission including caching or a sample return?

ANSWER 30:

The Mars 2020 rover mission continues the pursuit of the Mars Exploration Program's science theme of "*Seeking the Signs of Life.*" The mission objectives are to explore an astrobiologically relevant ancient environment on Mars and to search for potential biosignatures within that geological environment. This mission will enable concrete progress toward eventual return to Earth of carefully selected materials, thereby satisfying NRC Planetary Decadal Survey science recommendations, and it will provide

opportunities for accommodation of contributed Human Exploration and Operations payload element(s), technology infusion, and international participation.

Most recently, a Science Definition Team (SDT) completed work to outline the science requirements to meet the above objectives for Mars 2020 and in particular, recommended a cache on this mission. The complete SDT report can be found at http://mars.jpl.nasa.gov/mars2020/. At this time, the project team is assessing the engineering requirements and defining the overall mission concept, including the use of residual flight hardware and expertise from the Mars Science Laboratory (MSL) mission.

QUESTION 31:

There is a $17.7M reduction for Exploration in the budget for Stennis Space center. The justification is "decrease due to revised testing requirements to support the SLS program and completion of the A-3 test stand." Please clarify the revisions to the testing requirements and how much of the budget decrease is associated with those changes.

ANSWER 31:

NASA's strategy for Exploration is intended to balance early mission demonstration and future mission requirements within a sustainable budget profile. The SLS program Block 1 capability for first flight in 2017 has not revised its testing requirements at Stennis Space Center. The A-3 test stand activation and checkout testing is approaching completion. Further engine testing in support of Exploration on A-3 test stand is not planned at this time.

QUESTION 32:

We understand that NASA last year signed a task agreement with industry to fund work with Johnson Space Center to develop a prototype exploration suit. This proposed exploration suit architecture will include a demonstration on-board ISS. Is this a repurposing of the current Constellation Space Suit Contract (CSSS) to develop the next generation space suit capabilities and/or replace the ISS EMU, which is currently under contract to 2020? If NASA intends to replace the ISS space suit, will that effort be competed?

ANSWER 32:

NASA is developing the next generation exploration extra-vehicular activity (EVA) space suit with a combination of in-house risk reduction development and testing, and a contract for a certified EVA space suit.

Within the NASA Advanced Exploration Systems (AES) Division in the Human Exploration and Operations Mission Directorate (HEOMD), NASA civil servants at the Johnson Space Center (JSC) are developing an in-house prototype EVA suit and EVA life support system. This in-house development activity is utilizing NASA developed

technology along with contractor provided components from many providers. The objective of the in-house development activity is to gain operational and performance data on the new technology elements in ground simulation and testing environments.

NASA also has an existing contract, CSSS, with Oceaneering, awarded in June 2008, to develop a certified exploration-class EVA space suit. NASA is working with Oceaneering hand-in-hand during the in-house development period to share lessons learned during the risk reduction development and testing activities. After the risk reduction development and testing activities are completed, Oceaneering will build a certifiable exploration suit that will be tested on the ground with future plans to test onboard the International Space Station (ISS). It is critical that the new exploration EVA suit be tested on the ISS where the resources and operational margins are available before the new suit is utilized in environments beyond low Earth orbit (LEO) where repair opportunities and mission duration could be very limited in the event of EVA anomalies. This new exploration EVA suit will not replace the current ISS Extravehicular Mobility Unit (EMU). If NASA decides to replace the current ISS EMU, the Agency will perform a full and open competition.

QUESTION 33:

What is the timeframe for reformulation of future rotary wing related research? What specific goals do you have in reformulating this research area? How will this research be formally coordinated with other government agencies that conduct rotorcraft research?

ANSWER 33:

The reassessment and reformulation of rotary wing research will be worked throughout the remainder of FY 2013 and FY 2014. The goals of this reformulation include the following:

focus the NASA-funded research portfolio on areas that will have the most significance to the rotary-wing segment of the U.S. aerospace industry, with an emphasis on civil aviation priorities such as noise reduction, system reliability, and reduced operating costs (fuel efficiency).
Provide for long-term innovative possibilities that can be transformative, such as more electric and/or autonomous capabilities.

NASA will coordinate the reformulation of the rotary wing research with the U.S. Army. The Army is the DOD-designated lead service for rotorcraft. This coordination will occur through regular meetings with U.S. Army and OSD leadership.

QUESTION 34:

Has NASA terminated any Space Act Agreements in the past year? Under what circumstances? How was this process implemented?

ANSWER 34:

NASA terminated four Space Act Agreements (SAAs) during the past calendar year. Those four agreements are described in the table below. In each case, the termination was effected in accordance with the SAA's "Termination" article and a termination letter was sent to the partner.

Center	Partner	Description	SAA Type	SAA Signature Date	Termination Date	Reason for Termination
GSFC	BaySys Technologies, LLC	Aircraft modification activities	Reimbursable	7/31/06	8/20/12	Partner's failure to meet its responsibilities under the Agreement
ARC	Power Assure, Inc.	Testing Data Center Power Management and Monitoring Solutions at ARC Facilities	Non-Reimbursable	4/10/10	2/10/13	NASA determined that there was not a significant benefit from continuing the collaboration
HQ	Space Florida	Collaboration on "Nano Satellite Launch Challenge"	Non-Reimbursable	10/18/11	12/18/12	NASA decided to discontinue the Nano Satellite Launch Challenge.
HQ	Japan Aerospace Exploration Agency (JAXA)	Collaboration to test JAXA's full-scale rotor with active flap in the National Full-Scale Aerodynamics Complex	Non-Reimbursable	2/24/09	9/9/12	Budgetary constraints

		Foot Wind Tunnel at NASA Ames Research Center.				

QUESTION 35:

Are all Space Act Agreements available to the public? Does NASA maintain a centralized list of all Space Act Agreements? Is the public provided advance notice of potential Space Act Agreements?

ANSWER 35:

While all Space Act Agreements (SAAs) are generally available to the public upon request, occasionally, there may be proprietary information contained in a SAA that would not be made available publicly. The tests for whether a SAA contains any proprietary information that should be withheld from the public is evaluated consistent with 51 U.S.C. § 20131 "Public Access to Information" and the "Freedom of Information Act" (FOIA), 5 U.S.C. § 552. Both statutes protect trade secrets or confidential information as defined in those statutes. To the extent that information contained in a SAA meets the test of either statute, the information to be protected should be redacted prior to the release of the SAA to the public.

NASA utilizes two systems for storage of SAAs, one for domestic SAAs and the other for international SAAs. While the Agency does not maintain a centralized list of SAAs, reports can be generated by these two systems listing the SAAs for each type.

For those partnerships that involve activities that are likely to attract significant external interest, NASA often issues a press release coincident with the execution of the SAA.

QUESTION 36:

How does NASA ensure that Space Act Agreements are awarded fairly? Is there a competitive process?

ANSWER 36:

Yes. NASA's SAAs are generally executed on a nonexclusive basis such that all non-government parties should have equal access to NASA resources. Where exclusive arrangements are contemplated, NASA's SAA policy, NASA Implementing Instruction NAII 1050.1, "The Space Act Agreements Guide" (SAAG) states that competition should be used to the maximum extent practicable to select the Partner(s) as a mean of avoiding the appearance of favoritism. Announcement of such opportunities is made on the NASA Acquisition Internet Service, which may be supplemented through press releases.

QUESTION 37:

How does NASA ensure that Space Act Agreements do not unnecessarily compete with the private sector?

ANSWER 37:

Under NASA policy, the SAAG, NASA may enter into SAAs with non-government Partners to perform work on behalf of a Partner only under two conditions – [1] the activity must be consistent with NASA's mission; and [2] involve goods, services, facilities or equipment not reasonably available on the U.S. commercial market from another source. The second element of the above threshold is grounded in statute and Executive Branch policy. NASA may perform reimbursable work only if doing so does not result in the Agency competing with the private sector. This requirement is embodied in National Space Policy of the United States (June 28, 2010) which directs the Federal Government to "purchase and use commercial capabilities and services to the maximum practical extent when such capabilities and services are available in the marketplace and meet United States Government requirements... and to refrain from conducting United States space activities that preclude, discourage, or compete with U.S. commercial space activities, unless required by national security or public safety."

NASA's policy related to pricing any use of its facilities can be found in NPR 9090.1 "Reimbursable Agreements," and NPD 9080.1, "Review, Approval, and Imposition of User Charges." NPR 9090.1, Section 2.1.2 "Reimbursable Agreement Administrative Requirements" addresses limits on competition with U.S. commercial sources noting that legal or policy considerations can affect the circumstances under which the Agency can make specific types of facilities or services available to non-Federal entities if commercial services are otherwise available. Moreover, Section E.3.1 "Market-Based Pricing Procedures" addresses situations where for market-based pricing, the contemplated price is higher than the full cost of the work. It states that the pricing methodology is limited in this circumstance to prevent putting commercial providers of similar goods/services at a competitive disadvantage, should NASA's full cost be lower. NPD 9080.1 further addresses competition with the private sector, stating that "It is NASA policy not to compete with commercial entities in providing services or goods, property or resources to entities outside the Federal Government." Thus, legal and policy requirements ensure that NASA does not unnecessarily compete with the private sector.

QUESTION 38:

What is the ultimate goal of the Administration's reorganization of education programs?

a. What was your role in the organization process?
b. Which programs will you be responsible for managing?

ANSWER 38:

The ultimate goals of the Administration's reorganization of education programs are to: Reorient Federal policy to meet the needs of those who are delivering STEM education: school districts, States, and colleges and universities.

- Help in reorganizing efforts and redirecting resources around more clearly defined priorities, with accountable lead agencies;
- Enable rigorous evaluation and evidence-building strategies for Federal STEM education programs;
- Increase the impact of Federal investments in important areas such as graduate education by expanding resources for a more limited number of programs, while recognizing shortages in key disciplines and professions; and,
- Provide additional resources to meet specific national goals, such as preparing and recruiting 100,000 high-quality K-12 STEM teachers, recognizing and rewarding excellence in STEM instruction, strengthening the infrastructure for supporting STEM instruction and engagement; increasing the number of undergraduates with a STEM degree by one million, and broadening participation in STEM fields by underrepresented groups.

NASA has a long history of collaborating with the Department of Education, National Science Foundation and the Smithsonian Institution, including joint exhibit development, coordination on evaluation strategies, and shared priorities for STEM education. Additionally, NASA and NSF are the co-chairs developing the CoSTEM strategic plan.

NASA will maintain four key projects in its education portfolio: Space Grant, EPSCoR, MUREP, and GLOBE. NASA will focus on its two key strengths: 1) engaging undergraduate and graduate students in internships and fellowships; and, 2) providing opportunities for participatory and experiential learning activities that connect learners, educators and communities to NASA-unique resources.

QUESTION 39:

During the hearing you mentioned that the Executive Office of the President (EOP) is overseeing the proposed reorganization of all federal STEM education programs. Who in the EOP is in charge of the reorganization? Who are Leland Melvin and NASA working with on this proposal?

ANSWER 39:

The STEM consolidation effort is being coordinated by the Executive Office of the President, under the oversight of Dr. John Holdren, Director of the Office of Science and Technology Policy. NASA Associate Administrator for Education, Leland Melvin, is the co-chair of the FC-STEM Subcommittee, along with Joan Ferrini-Mundy of the National Science Foundation, and NASA's representative to the CoSTEM. The CoSTEM members are representatives of the thirteen Federal Agencies conducting STEM education and at the level of Associate Administrator or higher.

QUESTION 40:

What offices and people would be responsible for carrying on NASA's education and public outreach activities under the Administration's proposal? Do they have any experience with space-related education content? Have NASA employees worked with them in the past?

ANSWER 40:

NASA's Office of Education remains responsible for coordinating NASA's education efforts under the Administration's proposal. NASA's education team at Headquarters and the Centers is made up of education personnel with a long history of implementing space-related education content. It includes staff with expertise in academic teaching, informal education, K-12 instruction and supervision, grant management, program/project management, and STEM expertise. Additionally, many of NASA's education activities are implemented by grantees or cooperative agreement partners in universities, school districts and informal education institutions across the Nation.

Content and efforts that are no longer funded by NASA will be reviewed by the National Science Foundation, Department of Education and the Smithsonian Institution. Elements or activities that support the STEM consolidation goals will be considered for incorporation into the broader STEM consolidation efforts.

QUESTION 41:

What features make NASA's STEM education programs unique compared to the approach taken by other agencies? Are there concerns that these features may be lost as a result of the push to consolidate STEM education across agencies?

ANSWER 41:

NASA Education's vision is to advance high quality STEM education using NASA's unique capabilities. NASA embeds education professionals directly into its missions to ensure the results of its scientific discoveries, and the advances in engineering and technology are directly incorporated into education resources available to the Nation's educators. By directly aligning NASA's Mission Directorate content with education activities, the Agency can make available authentic STEM experiences such as developing payloads to launch on NASA assets, hardware on the International Space Station, and internships alongside NASA scientists and engineers possible. These connections serve as a way to inspire, engage and eventually employee enthusiastic students in the aerospace field. As part of the consolidation effort, NASA will work closely with the Department of Education, National Science Foundation, the Smithsonian Institution and other CoSTEM partners to ensure that the Agency's unique people, resources and facilities remain available to help inspire students and support educators.

QUESTION 42:

Earlier this year, the Space Subcommittee held a hearing on the Space Leadership Act, proposing some changes to the way NASA leadership is appointed and how long they can serve. Do you have any thoughts about that? Are there any lessons or advice you could share with us regarding this possible reform?

ANSWER 42:

The Administration has not taken a position on H.R. 823.

QUESTION 43:

The Administration's budget request proposes transferring funding for the Radioisotope Power System development infrastructure from the Department of Energy to NASA. A 2009 report from the National Academy of Science titled "Radioisotope Power Systems: An Imperative for Maintaining U.S. Leadership in Space Exploration" found that "roles and responsibilities as currently allocated between NASA and the Department of Energy are appropriate, and it is possible to address outstanding issues related to the. Short supply of Pu-238 and advanced flight-qualified RPS technology under existing organizational structures and allocation of roles and responsibilities."

a. Was this change requested by NASA or DOE?
b. Will any other agencies use these facilities? If so, will they contribute funding?
c. Will all funding decreases in DOE's budget be reflected as funding increases for NASA's budget?
d. Will NASA now be responsible for maintaining DOE infrastructure, safety, and operations?
e. What prevents NASA from taking this money and using it for other NASA (priorities, and leaving DOE's infrastructure to deteriorate?

ANSWER 43:

The Department of Energy (DOE) is responsible for maintaining the national capability to support the development, production and safety of radioisotope power systems (RPS) for national security and space exploration missions, which use plutonium-238 (Pu-238) as a heat source. NASA planetary missions are major users of RPS and the dwindling supply of Pu-238 has forced NASA to make mission-limiting decisions in the use of RPSs for science missions. NASA's planetary program depends on using RPS capability well into the future; therefore, the urgency to restart domestic production remains high. For these reasons, the Administration has requested, and Congress has agreed to, the restart of Pu-238 production beginning in FY 2011.

In FY 2014, DOE is transitioning to a full cost recovery strategy for RPS. NASA is the primary user of the relevant facilities, so the Administration's approach is for NASA to provide the full funding so that RPS program requirements and funding are aligned under

one agency. Requested FY 2014 funding and justification for the sustainment of all necessary supporting infrastructure and capabilities are included in the NASA budget request. The required funding for DOE RPS infrastructure covers maintaining unique program, facility and safety infrastructure in a safe, operable state to include: trained operators, accountability of nuclear material inventories, reliably operable equipment, up-to-date facility safety documentation, maintenance, utilities, waste management, technical and administrative support, and modeling and analysis capabilities. User programs pay incremental costs for mission-specific hardware and analyses.

NASA will be performing a zero-base review of the DOE RPS infrastructure in order to determine the necessary support that meets its needs. As part of this zero-base review, DOE will ensure that costs allocated to NASA exclude specialized equipment for non-NASA users. DOE will work directly with OMB to recommend funding for currently maintained infrastructure that should be supported by other user agencies.

Although funding for the sustainment of all necessary RPS supporting infrastructure and capabilities will be provided by user organizations, such as NASA, DOE maintains the responsibility for execution of radioisotope power system flight development, production, and safety, and management of the necessary infrastructure. NASA and DOE will negotiate an agreement for a new governance structure that will promote transparency, contain costs, establish effective oversight, and maintain an appropriate level of involvement for NASA in the maintenance of radioisotope power systems infrastructure and capabilities. As allocated in the FY 2014 budget request, DOE will continue to execute the Plutonium Supply Project to develop the infrastructure and capabilities to supply Pu-238 at an average rate of 1.5 kg/year, as determined by NASA's current mission needs.

QUESTION 44:

In February, NASA announced the creation of the Space Technology Mission Directorate. What is NASA's justification for creating a new mission directorate without explicit authorization from Congress?

ANSWER 44:

In establishing the Space Technology Mission Directorate as an organizational element, NASA has followed the rules for notification regarding reorganizations established in law. Specifically, the Administrator notified the House and Senate Committees on Appropriations, pursuant to Section 505, Division B, of the FY 2012 Consolidated and Further Continuing Appropriations Act (P.L. 112-55), by letter dated August 16, 2012, of his intent to further realign the functions of the Office of the Chief Technologist and to establish a separate Space Technology Mission Directorate. An information copy of this notification was provided to Chairs and Ranking Members of the Committee on Science, Space, and Technology. It is worth noting that the Title I of the NASA Authorization Act of 2010 (P.L. 111-267) authorizes specific funding levels for Space Technology within

levels authorized for Aeronautics. Furthermore, annual NASA appropriations legislation beginning in FY 2012 has included a separate appropriation for Space Technology.

QUESTION 45:

Does NASA intend to request that this Committee authorize a Space Technology Mission Directorate?

ANSWER 45:

NASA seeks authorization for Space Technology funding consistent with the President's FY 2014 request of $742.6M.

QUESTION 46:

If this year's NASA Authorization Bill did not include explicit authorization for a Space Technology Mission Directorate, would NASA keep this structure in place?

ANSWER 46:

The Space Technology Mission Directorate is an existing organizational element of NASA. It is NASA's plan to continue to implement Space Technology activities for which funding is authorized and appropriated through the Space Technology Mission Directorate.

QUESTION 47:

What is NASA's plan for ensuring a new mission directorate does not simply become a dumping ground for technologies that other mission directorates need, but are not willing to request funding for?

ANSWER 47:

The technology investment strategy for NASA's Space Technology Mission Directorate (STMD) is tied explicitly to guidance from the NASA's Space Technology Roadmaps as prioritized by the National Research Council report. The NRC space technology prioritization report was developed independently from NASA with inputs from the complete spectrum of the U.S. space enterprise. The Space Technology Mission Directorate aligns technology investment topics with the NASA Space Technology Roadmaps and the NRC recommendations through technology development efforts conducted at all 10 NASA Centers, with industry, small businesses and academia.

The charter for STMD makes it clear that the new Mission Directorate takes a balanced portfolio approach to its investment portfolio to include early stage conceptual studies of entirely new technologies; mid level technology development with ground-based testing and prototype validation; and relevant environment flight demonstrations to verify

mission infusion readiness. Such a portfolio-based approach ensures that the most urgently needed near term technologies are demonstrated and infused into future NASA missions quickly, while maintaining a pipeline for the technologies that will be needed in the future.

QUESTION 47a:

Conversely, what checks are in place to ensure that Space Technology does not develop systems that NASA does not have a practical use for?

ANSWER 47a:

As technologies progress from the early conceptual studies and prototyping phases, Space Technology strengthens the emphasis on technologies that have the greatest promise for improvements and efficiencies above currently available systems or capabilities. For example, before a technology or system is accepted for a technology demonstration mission, Space Technology works with Mission Directorates to determine the technology infusion paths within the Agency's exploration and/or science missions. In some cases, the primary infusion customer may be another government agency or a commercial space market. If a clear infusion customer, with timely needs demanding technology maturation, is not present, STMD does not embark on performing the demonstration mission. Even after project selection, a technology demonstration mission is reviewed at each key decision gate to determine if the infusion plan for the technology is solid and the technical objectives are still on track. Additionally, all technology demonstration projects are evaluated in terms of the crosscutting applicability to ensure the best value for the investment. The more potential infusion customers the more likely a given technology would be funded.

QUESTION 47b:

How will the Space Technology Mission Directorate develop of technologies that are optimized for both Human Exploration and Science?

ANSWER 47b:

STMD is developing technologies directly applicable to both human exploration and science missions.

In the Science arena, current STMD investments will demonstrate laser or optical communications to increase communications bandwidth of NASA's space communications assets allowing us to receive more data from spacecraft studying the far corners of our solar system. We are also developing space based atomic clock technologies to improve accuracy of navigation systems. Space Technology will demonstrate a Solar sail seven times larger than any solar sail tested in space to date; a technology with tremendous potential for future heliophysics missions. In each case, these demonstration missions will enable future science missions not possible today

while providing a backbone for capabilities that are of significant benefit to future human exploration missions. For example, both the laser communications and atomic clocks demonstration missions involve cost sharing by the Human Exploration and Operations Mission Directorate (HEOMD), indicating the level of synergy and cooperation.

To achieve our human spaceflight goals, there are many technological barriers as humans travel further from Earth. Exploration Technology Development (ETD) within the Space Technology budget is targeted specifically at human exploration technology needs. This currently includes investments in: high power solar electric propulsion, needed to efficiently transport resources to distant locations for human exploration; in-space cryogenic propellant storage and transfer, to reduce propellant boil off and meet propulsion stage capability needs for human exploration missions; next generation life support systems and in situ resource utilization technologies to reduce the burden of transporting consumables; advanced batteries and fuel cells to support longer spacewalks and more sustainable spacecraft and habitats. These ETD investments always occur in close cooperation HEOMD and where appropriate in direct partnership with Advanced Exploration Systems under HEOMD.

All of the technologies Space Technology is funding intend to provide new options for aerospace stakeholders working on NASA missions as well as other aerospace enterprise needs.

QUESTION 47c:

If the technology is not optimized to address specific requirements, how is NASA ensuring that it is managing finite resources efficiently?

ANSWER 47c:

As noted above, space technology investments balance prioritizations identified by the NRC report alongside specific requirements articulated by the other NASA mission directorates. However, to address the longer term technology needs for both science and human exploration requires STMD to look and plan for the long range goals of the Mission Directorates (as well as those of the greater aerospace enterprise), where specific systems and mission requirements are yet to exist. For example HEOMD has a long term goal of human exploration of Mars. To eventually achieve this goal will require the development of mission capabilities that are well understood, even if specific mission architectures have not yet matured.

By stepping out ahead of the mission development environment, Space Technology is able to tackle capability barriers that stand in the way including providing closed loop life support systems, radiation protection, and space power generation and storage. The technology solutions and performance levels needed in these areas for human exploration are not well defined. Nevertheless, we do understand that breakthrough capability enhancements are needed in these areas, which requires NASA to invest in entirely new ideas. By demonstrating smaller scale prototypes Space Technology identifies technical

solutions and brings new capabilities into the mission pipeline while buying down the technology risk to future missions.

QUESTION 48:

What distinguishes the Space Technology program from the technology being developed in the HEO and Science Mission Directorates?

ANSWER 48:

Space Technology investments address long-term Agency technology priorities and technology gaps identified by NASA Mission Directorates and within the Agency's space technology roadmaps. Space Technology is maturing early stage concepts and unproven technologies not yet identified for a specific mission and considered too high risk for SMD and HEOMD investments. By pushing promising technologies through the pipeline into ground-based testing, prototyping and relevant environment demonstrations, STMD is able develop capabilities for future science and human exploration missions, readying them for use by the other Mission Directorates. Thus distinct investment areas for STMD include: early stage new ideas, concepts and technologies that are decades out and may not have specific mission applicability and/or those which are considered too high risk for the other Mission Directorates until the technology is further proven. STMD also focuses on prototyping and ground testing of transformative concepts that might completely revolutionize current mission assumptions and conducts relevant environment technology demonstration missions where the underlying technology has crosscutting applicability both within NASA and for other government agencies and the commercial space sector.

Maturing technologies from idea and concept inception all the way through demonstration in a relevant environment is a significant challenge, and comes with inherent technical and programmatic risk. By supporting projects at all technology readiness levels, Space Technology is able to create a technology cascade, resulting in mature, ready-to-infuse technologies that increase the nation's in-space capabilities.

QUESTION 49:

Which mission directorate will be responsible for paying for solar electric propulsion after Space Technology completes the development phase?

ANSWER 49:

Less capable Solar Electric Propulsion (SEP) systems are available now and have been used for a variety of spacecraft over the last decade to manage station keeping and provide continuous thrust for deep space missions with the appropriate mission profile. For NASA, this included Deep Space 1 and Dawn, which is on course for reaching the Ceres asteroid in 2015. The current SEP system being developed for a demonstration class mission will provide between 30 and 50 kilowatts of power. The final objective

system that HEOMD envisions for its deep space exploration missions involves a 300 kilowatt system. To permit the development of a 300 kilowatt system, many technology elements including: advanced high power solar arrays, advanced high power thrusters and a new generation of power management and power processing systems, will be needed relative to current SEP capabilities. The main purpose of the 30 kW demonstration class system is to develop, integrate and demonstrate these advanced component technologies such that clear extensibility to the 300 kW HEOMD systems is validated. In turns out that such a 30 kW demonstration system can also be directly applied to science as well as DoD missions not feasible today. Furthermore the component technologies, particularly the advanced solar arrays, will have direct commercial applicability to future communications satellites.

The intent for STMD is to perform the development of the technology components, as well as fund the integration and flight demonstration of a 30 kW class high power SEP system. With the hard part of the technology development addressed, the customized development and design for specific Science and human exploration needs would be done by the Science and Human Exploration and Operations Mission Directorates in conjunction with their regular mission planning efforts.

QUESTION 50:

There have been multiple, independent allegations made by current and former NASA employees that suggest systemic security deficiencies at NASA Research Centers and partner organizations, which may have resulted in unauthorized disclosures of sensitive information to, among others, China. NASA is explicitly prohibited from forming bilateral relationships with China. Yet, you told the House Committee on Appropriations that 192 Chinese nationals have physical access to NASA. It was also later discovered that NASA employs 118 Chinese nationals in "remotely-based" information technology jobs that may enable them to penetrate the space agency's national security database servers. That is over 300 Chinese nationals working for or with an agency that is explicitly prohibited from working with Chinese nationals. While simply working at a NASA facility may not constitute bilateral relations, it would appear that NASA is circumventing, if not the letter of the law, at least the spirit of the law. Please explain.

ANSWER 50:

NASA is committed to complying with restrictions in Section 535 of the Consolidated and Further Continuing Appropriations Act, 2013 (P.L. 113-6), which prohibit using NASA funds for participating, collaborating, or coordinating bilaterally with China or any Chinese-owned company. Accordingly, NASA has declined all bilateral engagement with China and Chinese-owned companies. The Agency has not permitted, since enactment of the limitation in P.L. 112-10, P.L. 112-55, and P.L. 113-6, any visit to a NASA-owned or -utilized facility by any official Chinese visitors where such a visit effectuated the bilateral participation, collaboration, or coordination with China or a Chinese-owned company.

NASA has also suspended all agreements with China, and published both a Procurement Information Circular (PIC) (PIC 12-01A) and a Grant Information Circular (GIC) (GIC 12-01) to publicly advise all of its contractors and grantees – including hundreds of U.S. universities that might otherwise receive NASA sponsorship for fundamental scientific research – of the restrictions on the use of NASA funds.

Upon receipt of a request for physical or remote access to a NASA facility by a Chinese national, NASA conducts a thorough review to ensure compliance with P.L. 113-6, in addition to the standard security and export control reviews for foreign national access. When these reviews are complete and the access is deemed to be programmatically beneficial to NASA, access is granted to those that are lawfully-admitted for permanent residence in the United States (LPRs or "green card holders") or those that hold U.S. visas, such as an F-1 student visa. In each instance, NASA ensures that the Chinese national does not have an affiliation with China or a Chinese-owned company. Most commonly, the Chinese national is a student or post-doc at a U.S. university that is a NASA project grant recipient.

With regard to official Chinese visitors, in consultation with Agency counsel, NASA believes that it is not inconsistent with P.L. 113-6, subsection (b) to host meetings of a very limited set of multilateral institutions that include official Chinese participation at NASA facilities. As such, in two specific instances, in the case of the International Space University (ISU) at Kennedy Space Center (KSC), June 2012, and the Consultative Committee for Space Data Systems (CCSDS) and Interagency Operations Advisory Group (IOAG) at KSC, December 10-13, 2012, NASA hosted official Chinese visitors participating exclusively in multilateral meetings under the auspices of these multilateral organizations.

In such cases, all NASA Centers are required to follow specific protocols to ensure that visits by foreign nationals from countries such as China do not pose a threat to the Agency's safety or security, including the security of technology. These include limited access only to information that is in the public domain, and no access to classified, sensitive but unclassified or export-controlled information or hardware. All such visitors must be escorted at all times and are not permitted access to any non-public U.S. Government or NASA technical data.

Additional information related to foreign national access to NASA facilities are reflected in the responses to QFRs 51-55.

QUESTION 51:

Has each and every Chinese national with physical or remote access to NASA and NASA information been thoroughly vetted and has NASA provided the mandated certification to Congress that there is no risk of the transfer of technology, data, or other information with national security or economic security implications to China or a Chinese-owned company? Does NASA's review of these individuals include an assessment of their connections to foreign governments? Does NASA believe a standard National Agency

Check with Inquiries (NACI) is sufficient to protect national interests? Would NACI reviews identify a foreign nationals' relationship with state entities? Does NASA take additional measures to review foreign nationals such as those required by the National Industrial Security Program operating manual?

ANSWER 51:

For each physical or remote access request for a Chinese national, NASA determines that the Chinese national does not have a current affiliation with China or a Chinese-owned company.

NASA does not believe a standard National Agency Check with Inquiries (NACI) is sufficient to protect national interests nor would the NACI reviews identify a foreign nationals' relationship with state entities. To mitigate the risk and to augment NASA's vetting processes for foreign nationals, eCustoms Visual Compliance checks are conducted for all foreign nationals. The data bases associated with this checks are listed below. Referrals for additional checks are also made to the Office of Protective Services (OPS) Counterintelligence Division for foreign nationals from Designated Countries. In addition, NASA's reviews foreign nationals for all measures that are described in the National Industrial Security Program operating manual.

eCustoms Visual Compliance Database Checks:

- Department of Commerce Denied Persons [BIS]
- Department of Commerce Entity List [BIS]
- Department of Commerce "Unverified" List [BIS]
- Department of Treasury Specially Designated Nationals and Blocked Persons, including Cuba and Merchant Vessels, Iran, Iraq and Merchant Vessels, Sudan Blocked Vessels [OFAC]
- Department of Treasury Specially Designated Terrorist Organizations and Individuals
- Department of Treasury Specially Designated Narcotic Traffickers and Narcotics Kingpins
- Department of Treasury Foreign Narcotics Kingpins
- Department of Treasury Palestinian Legislative Council List (PLC)
- Department of State Designated Terrorist Organizations
- Department of State Terrorist Exclusion List (TEL)
- U.S. Federal Register General Orders
- Department of State Arms Export Control Act Debarred Parties
- Department of State International Traffic In Arms Regulations Munitions Export Control Orders
- Department of State Nonproliferation Orders
- Department of State Missile Proliferators
- Department of State Chemical and Biological Weapons Concerns
- Department of State Lethal Military Equipment Sanctions

- Foreign Persons Designated Under the Weapons of Mass Destruction Trade Control Regulations
- U.S. General Services Administration (GSA) List of Parties Excluded from Federal Procurement Programs
- U.S. General Services Administration (GSA) List of Parties Excluded from Federal Nonprocurement Programs
- U.S. General Services Administration (GSA) List of Parties Excluded from Federal Reciprocal Programs
- U.S. Office of the Inspector General List of Individuals/Entities Excluded from Federal Health and Medicare Programs
- Air Force Office of Special Investigations — Top Ten Fugitives
- Bureau of Alcohol, Tobacco, Firearms and Explosives Most Wanted
- Department of Homeland Security Most Wanted Fugitive Criminal Aliens
- Department of Homeland Security Most Wanted Human Smugglers
- FBI Hijack Suspects
- FBI Most Wanted Terrorists
- FBI Seeking Information
- FBI Ten Most Wanted Fugitives
- FBI Wanted Fugitives
- Food and Drug Administration — Clinical Investigators
- Food and Drug Administration — Debarment List
- Food and Drug Administration — Disqualified and Restricted
- Immigration and Customs Enforcement Most Wanted Fugitives
- Naval Criminal Investigative Service — Wanted Fugitives
- Office of Research Integrity PHS Administrative Actions
- OSFI Consolidated List — Office of the Superintendent of Financial Institutions
- OSFI Warning List — Office of the Superintendent of Financial Institutions
- Patriot Act Section 311
- Politically Exposed Persons (PEP)
- U.S. Drug Enforcement Administration — Major International Fugitives
- U.S. Marshals Service — Major Fugitive Cases
- U.S. Marshals Service — Top 15 Most Wanted
- U.S. Postal Inspection Service — Most Wanted
- U.S. Secret Service — Most Wanted
- World Bank Listing of Ineligible Firms

QUESTION 52:

A recent report by the information security firm Mandiant indicated that there was a connection between China's People's Liberation Army and certain Chinese research and academic institutions. What does NASA do to review any possible connection between Chinese researchers at NASA facilities and the Chinese government?

ANSWER 52:

NASA depends on both the eCustoms Visual Compliance check of United States Government lists (see above) and a special review by the NASA counterintelligence/counterterrorism (CI/CT) program.

QUESTION 53:

The 192 Chinese nationals with physical access, not to mention the 118 with varying levels of remote access, are significantly more than the number disclosed by the NASA Inspector General's office in June 2012. How do you explain the discrepancy?

ANSWER 53:

NASA is not aware of any report by the NASA Office of the Inspector General (OIG) from June 2012 that included numbers for Chinese nationals. NASA checked with the OIG and they confirmed that they did not prepare any such report, nor did they have any record of having provided any such numbers as part of a Congressional inquiry. Therefore, we believe that you may be referring to correspondence that NASA sent to Congressman Rohrabacher, dated June 20, 2012, that responded to his questions about the number of Chinese foreign nationals that NASA allows to have access to its facilities. Data from this letter was referenced by Chairman Wolf at a March 20, 2013, hearing before the House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies, at which Administrator Bolden testified.

In the aforementioned June 20, 2012, letter to Congressman Rohrabacher, NASA noted that, as of March 2012, NASA had identified 293 citizens from the People's Republic of China (PRC) who were approved for either physical access to NASA facilities or remote IT access. The 293 total cited in this letter included two categories of PRC citizens: 1) People who are citizens of PRC and have entered the United States via the visa process and who are not Lawful Permanent Residents (LPRs) of the United States; and, 2) People who are LPRs (i.e., green card holders) and who are still citizens of the PRC. For export control purposes, LPRs are treated as U.S. citizens.

On March 20, 2013, NASA provided similar data for Chairman Wolf – information that was also provided on March 29, 2013, to the Staff Director of the House Space Subcommittee, per his request. (Note, the information was provided with a Sensitive but Unclassified coversheet to both Chairman Wolf and to the Staff Director of the House Space Subcommittee, given the detailed sensitive data contained within.) In general, however, for this 2013 data compilation, NASA used the same processes as we did with the 2012 data compilation. Therefore, as of March 13, 2013, NASA had identified 310 citizens from the PRC (192 for physical access and 118 for remote IT access, as cited in the incoming question) who were approved for varying levels of access to NASA facilities or remote IT resources.

When comparing the two aforementioned data compilations, there is an increase of only 17 PRC citizens between the two timeframes. We therefore disagree that there are "significantly more" Chinese foreign nationals who had access to NASA facilities or remote IT resources as of March 13, 2013, as compared to those who had access as of March 2012.

QUESTION 54:

In March, you told the House Committee on Appropriations that NASA has 281 foreign nationals from 'designated countries' who have physical access to NASA facilities. Designated countries are those that support terrorism, are under sanctions or embargo, and countries of "Missile Technology Concern" such as China, Iran, North Korea, Burma, Eritrea, Sudan, Uzbekistan, and Saudi Arabia. It would seem to me that NASA is inviting trouble. Have all 281 foreign nationals been thoroughly vetted? Please describe the process.

ANSWER 54:

After a civil servant has confirmed that the foreign national user has a valid need to access NASA facilities or assets, the Center International Visit Coordinator (IVC) executes an investigation check. NASA uses a third party tool to execute a foreign national investigation called "Visual Compliance." Created by eCustoms, Visual Compliance allows NASA to quickly complete a Restricted Party Screening against all relevant U.S. Government lists including:

- Specially Designated Nationals and Blocked Persons (SDN)
- Department of Treasury Office of Foreign Assets Control (OFAC) Sanctions
- Department of Commerce Bureau of Industry and Security (BIS) Denied Persons List
- Department of Commerce BIS Entity List and Unverified List Department of State Arms Export Control Act Debarred Parties
- Department of State Designated Terrorist Organizations
- Department of State Nonproliferation Orders Screen against a comprehensive inventory of U.S. law enforcement, military, public service, banking, and international lists (including Japan Foreign End-Users of Concern, the United Nations and European Union lists of terrorist suspects, and Interpol.

If no findings are discovered, the Foreign National request is then forwarded to the Center Export Control for review and documentation of the access limitations (provisos/conditions). Once Center Export Control has completed their activities, the Center IVC again reviews the request for any anomalies and if approved, then the request/identity is approved. The user or requestor can then request access to specific logical assets.

The request is sponsored for verification of need. If an application is marked as containing export control data, then the Center export control reviews the request prior to

the application approves access. The application approvers review the export control provisos/conditions for the foreign national user before granting access.

For access requests for foreign nationals from Designated Countries, all of the above procedures apply, plus, at the direction of the Assistant Administrator for Protective Services, beginning in 2012, Counterintelligence Officers are notified of access requests from all foreign nationals from Designated Countries, including lawful permanent residents from those countries, and may make additional inquiries. Once the Center Export Control official has completed his review, the request is forwarded to the Agency Desk Officer assigned to that country and associated mission activities for review. The Agency Desk Officer reviews the document, after which it is additionally reviewed by the Agency Export Control office. Finally, the Agency IVC reviews and either approves or disapproves the requested access.

QUESTION 55:

Does NASA have enough security and counterintelligence personnel to protect against foreign intelligence threats? How many individuals are responsible for this effort?

ANSWER 55:

Like all Federal agencies, NASA's personnel, property and information resources are under constant attack from adversaries both at home and abroad. The very nature of NASA's mission, and the extremely important technical and intellectual capital produced therein, makes all Agency resources a valuable target for hackers, criminals, and foreign enterprises. Many of these threats are well resourced, highly motivated, and exhibit varying levels of sophistication. Therefore, Agency security is and will remain a top priority for NASA.

Although these are challenging budgetary times for the Nation and subsequently for NASA, the Agency is very proud of the work our security personnel do on a daily basis with available resources in order to respond to and thwart an ever-growing number of and type of malicious threats against Agency resources. On a daily basis, security personnel from across the Agency are successfully working together to ensure that Agency resources are safeguarded from attack, assessed against stringent Federal and Agency security requirements, and continuously monitored for compromise and for the effectiveness of protective measures. However, NASA recognizes that vigilance at all levels is essential to thwarting such attacks. Therefore, NASA senior leaders continue to prioritize a culture of security awareness across the Agency, to include new and expanded security training for all NASA employees, and contractors – not just those in formal security roles. NASA takes any allegation of a security violation very seriously, and we follow long-established procedures to investigate these allegations quickly and thoroughly and to prosecute all security violations, whether foreign or domestic.

Within NASA, multiple offices are tasked with the responsibilities of securing NASA's resources. They are: (1) the Office of the Chief Information Officer (OCIO), with

statutory responsibility for all unclassified information technology and unclassified information; (2) the Office of International and Interagency Relations (OIIR), with designated responsibility for Export Control; and, (3) the Office of Protective Services (OPS) which is responsible for all of NASA's physical, personnel and information security policies for classified systems and headquarters administration activities, protection program management and emergency management, intelligence reporting and analysis, special access programs, communications security (COMSEC), operation of all NASA's classified national security systems, and all counterintelligence and counterterrorism activities agency-wide.

The mission of the Counterintelligence (CI)/Counterterrorism (CT) Division provides specialized CI/CT services to NASA personnel and resources to detect, deter, and neutralize threats posed by foreign intelligence and terrorist activities. The NASA CI/CT program works in concert with the United States counterintelligence community to increase CI/CT threat awareness and education among NASA personnel, and to detect and disrupt the effectiveness of foreign intelligence officers, assets, operations, and terrorist elements targeting NASA. OPS Counterintelligence is also actively engaged with NASA programs and projects as part of an education and awareness program as well as looking for any indicators that may be of concern. In addition, the CI/CT Division has 20 Special Agents located at the NASA Centers who report directly to the Headquarters CI/CT Division Director. Because NASA faces a growing need for more counterintelligence personnel to protect against foreign-intelligence threats, the OPS Assistant Administrator increased personnel numbers for the counterintelligence program by 25 percent over the last 12 months by evaluating requirements and re-purposing existing OPS personnel.

Center Protective Services activities are under the control of the Center Director. Center Protective Services Offices are staffed with personnel that perform security related duties such as; information security, personnel security, emergency management, international visitor control, export control, industrial security, physical security, and armed uniformed security officers. The Centers also has layers of security (perimeter fences, CCTC, foot/mobile patrols, electronic readers, etc…) in place that prevents a foreign national from entering an area outside the scope of their visit. Functional responsibilities include leadership, management and direction for all protective services disciplines as they apply to the protection of people, information, and property.

QUESTION 56:

What is the timeframe for across the board application of the Personal Identification Verification cards?

ANSWER 56:

NASA met the initial Personal Identification Verification (PIV) issuance requirement in October 2008. PIV enabled physical access has been in place since 2008. PIV enabled network access has been in place since 2010. PIV enabled application access is in

progress. The NASA-wide PIV mandatory pilot began in FY 2013 and is progressing towards a production rollout before the end of FY 2013. All windows systems are expected to be complete by Q4 FY 2014. Enabling PIV card log in of non-windows systems will take longer, depending on availability of third party products, funding for the products, integration, testing, and deployment.

QUESTION 57:

The Center for the Advancement of Science in Space or CASIS experienced a rough start. How is CASIS operating now and what is NASA doing to ensure that the National Lab portion of the station is being utilized to its full potential? What metrics does NASA use to evaluate the effectiveness of CASIS management?

ANSWER 57:

CASIS formally established a new Board of Directors comprised of national leaders in research and technology development in November 2012, and is working to define its strategy for management of the non-NASA utilization of the ISS National Laboratory.

While NASA's Space Life and Physical Sciences Research and Applications (SLPSRA) division acts as the liaison between the Agency and the Center for the Advancement of Science in Space (CASIS), SLPSRA does not manage CASIS or determine the research priorities for use of the International Space Station (ISS) as a National Laboratory; CASIS will have the responsibility for determining those priorities. NASA believes this will help ensure that research from a wide range of disciplines is carried out aboard ISS.

CASIS works to an Annual Program Plan (APP), which stipulates yearly goals for the organization. CASIS provides NASA quarterly status reports, including end-of-year reports, which provide updates of work done vs. the APP.

QUESTION 58:

What is your confidence level that CASIS will be able to meet all of NASA's requirements going forward?

ANSWER 58:

NASA is not aware of any management issues or funding constraints that could limit or restrict the ability to fully utilize the ISS National Lab.

QUESTION 59:

This budget request asks NASA to pay for many other agencies' work. It asks NASA to pay for NOAA's climate sensors, USGS' remote sensing development, and DOE's radioisotope infrastructure- all with a $55M reduction from FY 2012 levels (or roughly a $178M cut from FY 2013 estimates).

a. Why is NASA being asked to bear the burden of other agencies' requirements when it can't afford its own responsibilities?

ANSWER 59:

NASA continues to maintain a balanced portfolio of missions. As the Nation's civil space agency, NASA expertise is brought to bear effectively in the design, implementation, and in some cases the continuity of Earth observing missions whose measurements are useful both to NASA research and applications development, and to further the objectives of other government agencies. Just as the Earth is an integrated system, sustained observation of the Earth requires an integrated and collaborative approach across all agencies in order to minimize and fully leverage the Nation's investments. In the case of radioisotope power systems, NASA is the sole current user for the infrastructure, so having NASA budget for this infrastructure will best facilitate the reconciliation of capability with demand.

QUESTION 60:

What has NASA done to develop a roadmap for the future of human exploration which defines key milestones and decision points for an expanded human presence in the solar system?

ANSWER 60:

NASA is currently implementing its Capability Driven Framework (CDF) strategy for human space exploration with the ultimate goal of crewed surface missions to Mars. The CDF is a strategic roadmap that differs from previous major space programs and will ensure that the United States fosters a safe, robust, affordable, sustainable, and flexible space program by developing a set of core evolving capabilities instead of specialized, destination-specific hardware, to achieve an expanding human presence across the solar system. The core systems capabilities include human-robotic mission operations; communications and navigation; power and energy storage; advanced propulsion; ground operations; habitation; mobility; radiation mitigation; crew health and protection; entry, descent, and landing; environmental control and life support systems; and in-situ resource utilization.

NASA is looking carefully at each of these technology and capability areas to identify development plans, which reflect maturation of the Technology Readiness Levels (TRLs). As funding and partnerships with commercial or international partners allow, missions will be assembled from these capabilities to further the exploration goals along the CDF. NASA is currently developing the Space Launch System (SLS) and Orion crew vehicle that will provide the initial capability for crewed exploration missions beyond low-Earth orbit (LEO) with an initial exploration mission flight test in 2017. In parallel, the other core systems capabilities will be developed, prioritized, and matured to ensure meaningful progress for human exploration beyond LEO. Beginning with

exploration systems testing on the International Space Station, followed by the initial Orion/SLS flight tests and along with the Asteroid Redirect Mission (ARM), NASA will demonstrate evolution of critical technologies, techniques, and operations in the near-term that will be required for future Mars exploration systems and allow humans to safely travel across and explore the solar system.

QUESTIONS FOR THE RECORD TO NASA ADMINISTRATOR CHARLES BOLDEN
RANKING MEMBER DONNA EDWARDS
SUBCOMMITTEE ON SPACE
APRIL 24, 2013 HEARING ON
"An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2014"

QUESTION 1:

GAO's latest report, NASA: Assessment of Selected Large-Scale Projects recognized that NASA's performance of its major projects had improved in the areas of cost and schedule growth. However, GAO also concluded that NASA will have limited flexibility to address potential cost growth or begin new projects over the next 5 years. In light of GAO's assessment, including its warning that NASA's ability to begin new projects will be difficult over the next 5 years, what do you see as the priorities for NASA and the civil space program?

ANSWER 1:

NASA's main priorities include the full utilization of the International Space Station (ISS) and the servicing of ISS by commercial cargo and crew vehicles; the development of NASA's beyond-low-Earth-orbit (beyond LEO) exploration capabilities, including the Orion spacecraft and the Space Launch System (SLS); the development of the James Webb Space Telescope (JWST); and advancing space technology efforts.

QUESTION 1a:

How does the proposed asteroid capture and retrieval mission fit within those priorities?

ANSWER 1a:

The Asteroid Redirect Mission is composed of three separate and independently compelling elements that leverage capabilities and technologies currently under development: the detection and characterization of candidate near-Earth asteroids; the robotic rendezvous, capture, and redirection of a target asteroid to the Earth-Moon system; and the crewed mission to explore and sample the captured asteroid using the Space Launch System (SLS) and the Orion crew capsule. These elements employ the priorities of Orion and SLS and space technology, particularly in the area of solar-electric propulsion (SEP).

QUESTION 1b:

Why does NASA believe the asteroid initiative is the best use of its limited exploration resources?

ANSWER 1b:

This mission to identify, capture, redirect, and sample a small asteroid would mark an unprecedented technological feat that will raise the bar of what humans can do in space. And it would provide invaluable new data on the threats asteroids pose to our home planet and how they could be mitigated. Capturing and moving an asteroid integrates the best of our science, technology and human exploration operations and draws on the innovation of America's brightest scientists and engineers. It takes advantage of our hard work on the Space Launch System and Orion crew capsule and helps keep us on target to reach the President's goal of sending humans to Mars in the 2030s.

In designing this mission, NASA is leveraging programs already in development, creating innovative new capabilities, and assuring affordability via an overall management strategy that draws deeply from the Agency's skilled workforce and applies varied acquisition and technology maturation processes from around the Agency. The robotic mission segment, to rendezvous, capture, and redirection of a target asteroid to the Earth-Moon system, would also demonstrate new advanced solar electric propulsion technologies, capable of generating the higher levels of thrust and power necessary to capture and redirect a large object. NASA will also refine and adopt in its spacecraft designs new advances in a variety of areas, including lightweight materials, communication, data storage and transfer, and space navigation. The crewed mission will travel deeper into space than ever before to conduct advanced exploration and research with the target asteroid, and return samples of the asteroid to Earth.

NASA's current analysis maintains the life cycle cost for the Asteroid Redirect Robotic Mission (excluding SLS and Orion) is less than $2B. There are no alternatives for an early SLS and Orion exploration mission that can be accomplished within this cost estimate.

QUESTION 1c:

Is the Administration going to provide to NASA the additional resources required to carry out an asteroid mission or is it going to require NASA to cannibalize other important activities?

ANSWER 1c:

NASA's strategy for an asteroid redirect mission is to leverage on-going activities, which individually provide technology advancements or new capabilities for human exploration, science and commercial applications. Funding provided within the President's FY 2014 budget request will augment our existing activities in Space Technology, Science, and Human Exploration and Operations to: enhance our near-Earth asteroid detection and characterization assets; accelerate advanced solar electric propulsion development; and, capture and maneuver of non-cooperative targets in space. The capability developments in FY 2014 are important in their own right independent of the proposed asteroid strategy. We will also begin planning for a robotic mission concept which leverages

technology advancements and flight demonstration plans for advanced high power solar electric propulsion technology.

Continued progress on the mission is conditional upon identification of a technically and programmatically feasible concept. NASA anticipates completing this summer an internal review of the redirection mission to assess technical and programmatic aspects of the mission. Budgetary findings of this review will be integrated into budget planning for FY 2015 with other priorities. We will keep the Committee apprised of progress.

QUESTION 2:

Your prepared statement references going to Mars in the 2030s. Is there a human exploration plan and roadmap to get there? If so, please provide the plan and roadmap to the Committee and describe how the proposed asteroid mission fits within that overall roadmap. What will the nation get out of the proposed asteroid mission that will help us get to Mars?

ANSWER 2:

NASA is currently implementing its Capability Driven Framework (CDF) strategy for human space exploration with the ultimate goal of crewed surface missions to Mars. The CDF is a strategic roadmap that differs from previous major space programs and will ensure that the United States fosters a safe, robust, affordable, sustainable, and flexible space program by developing a set of core evolving capabilities instead of specialized, destination-specific hardware, to achieve an expanding human presence across the solar system. The implementation of NASA's CDF strategy begins with exploration systems testing on the International Space Station (ISS), followed by the initial Orion/SLS flight tests.

The operational experience, technology demonstrations, and risk reduction for future crewed missions to Mars obtained on the ISS will be complemented by early operations with the Orion and Space Launch System and advancements of emerging technologies in exploration systems. The ISS provides critical capability not achievable on any other existing platform, such as long duration human health and performance, human life support systems, including maintenance and repair, and new technology and capability use.

Early beyond-Earth-orbit missions utilize human spaceflight capabilities currently under development in important ways in the early 2020s. Astrodynamically stable regions in the lunar vicinity offer locales for early operational experience in deep space. The crewed mission to a redirected asteroid would enhance current test objectives for early flights of SLS and Orion to provide important additional experience in human spaceflight beyond Earth orbit toward the ultimate goal of a crewed mission to Mars. The round-trip missions greater than 20 days to the asteroid will include highly limited resources and no ability to quickly return/abort to Earth coupled with operation of the Orion crew vehicle during missions to encounter and sample the asteroid. The complex trajectories in the

trip to the asteroid in a distant retrograde orbit around the Moon; rendezvous and proximity operations using the Orion spacecraft in deep-space environments; deep-space operations such as guidance, navigation and control nine days away from Earth; EVAs in this deep-space environment to explore the asteroid, and extraction, management; and return of samples in the Orion will all be challenging and inspirational early operations in translunar space that retire significant risk in preparation for future Mars missions.

In addition, the radiation environment in this region of space outside the Earth's Van Allen radiation belts is quite different than that encountered by astronauts on the ISS. Thus, we will gain invaluable experience with radiation dosages as well as the character/composition of the radiation experienced inside the Orion vehicle, but without the dangerous levels of exposure projected for long duration (> 6 months) trips. The radiation environment here is scalable to that expected for astronauts and spacecraft in deep space journeys such as one to Mars.

The combination of long duration human spaceflight on the ISS and initial beyond-Earth-orbit missions to a lunar distant retrograde orbit will stretch our human spaceflight capabilities in a safer approach than very long journeys of many months to a year.

The ARM and exploration missions demonstrate the CDF strategy, leveraging diverse capabilities across the Agency, to test and evolve critical technologies, techniques, and operations in the near-term that are required for future Mars exploration systems.

QUESTION 3:

What criteria will NASA use to determine whether or not ISS operations should be extended past 2020 and when will NASA carry out this assessment?

ANSWER 3:

NASA is currently in formulation discussions in regard to future operations of the ISS beyond the current budget cycle. Research onboard the ISS is advancing our understanding of human health and biology that may enable the development of medicines or procedures that will benefit people on Earth. Earth and space science research onboard the ISS is advancing our understanding of the atmosphere, oceans, and land use here on Earth as well as our understanding of astrophysics. Through the ISS program, NASA is also partnering with American industry in the development of a commercial demand driven market in LEO beyond government needs including crew and cargo transportation as well as commercial market driven research. Operations and technology demonstrations onboard the ISS are also enabling NASA to advance the capabilities needed to send humans beyond LEO and onto Mars. The ISS International Partnership provides the basis for enabling future exploration mission partnerships with the most advanced space fairing nations. Any decision to extend the ISS will weigh the value of continuing these activities against the costs of continued operations.

QUESTION 3a:

For how many more years could the ISS operate safely?

ANSWER 3a:

The lifetime extension data that NASA and the ISS Partnership have reviewed to date indicates that extension to 2028 is technically feasible.

QUESTION 3b:

What specifically is the ISS supposed to accomplish by 2020?

ANSWER 3b:

The objectives of the ISS are multifold: Advance benefits to humanity through research; enable a commercial demand driven market in LEO for transportation and research; enable the capabilities and conduct research needed to advance human spaceflight beyond LEO and onto Mars; utilize the ISS to demonstrate technologies for exploration beyond LEO; and provide the basis for international cooperation for international human spaceflight exploration.

With U.S. assembly only being completed in the summer of 2010, NASA is in the early stages of realizing these objectives. Research being conducted onboard the ISS in the fields of human health and performance, biology, and medical science are only starting to be applied here on Earth. There are still many fields of discovery such as research into cancer, the nervous system and osteoporosis that have yet to be fully explored onboard the ISS.

NASA expects to be able to purchase commercial crew transportation services from the private sector in the 2017 timeframe. One of NASA's commercial cargo providers has begun supplying the ISS and expects the second provider to demonstrate cargo supply capability in the August/September timeframe. NASA, in cooperation with CASIS, is fostering the expanded use of the ISS for commercial research and applications in the areas of pharmaceuticals, medical equipment and medical procedures.

NASA is conducting research into human health and performance for long duration spaceflight beyond low earth orbit. NASA's Human Research Program (HRP) uses the ISS to investigate and mitigate the highest risks to human health and performance, providing essential countermeasures and technologies for human space exploration. Risks include physiological effects from microgravity and radiation, as well as unique challenges in medical treatment, human factors, and behavioral health support. NASA is also conducting operational and technology demonstrations onboard the ISS to advance the biomedical capabilities needed to extend human spaceflight beyond LEO onto Mars.

The ISS, as an orbiting, biomedical space laboratory, provides an invaluable platform to

secure knowledge, test countermeasures, and evaluate technologies important for the development and validation of health risk mitigation techniques for exploration missions. The human research plan for various risks is laid out as a progression of activities that are designed to address critical questions that must be answered to quantify the risk or develop mitigation strategies for the risk. The ISS is necessary to mitigate over 20 human health risks areas anticipated on exploration missions. The human health and performance risk areas to be addressed through research on the ISS include, but are not limited to, inadequate nutrition, human behavior issues, technical capability limitations, radiation exposure, osteoporosis, re-adjustment to gravity, reduced muscle mass, reduced aerobic capacity, cardiac rhythm issues, damage to intervertebral discs, altered immune response, vestibular/sensorimotor alterations, fatigue, bone fracture, renal stone formation, intracranial pressure, host-microorganism interactions, and decompression sickness. NASA is currently assessing the progress of our human research program towards its goals.

As a technology development and demonstration platform for exploration, the ISS is currently being utilized to demonstrate advances in life support systems, robotics for crew support and spacecraft servicing, and space-durable materials. NASA is also funding technology development activities that will eventually be demonstrated onboard the ISS such as EVA systems, radiation monitoring, docking systems, and autonomous mission operations. These and other technology development activities are being driven by NASA's overall exploration goals to extend human presence beyond LEO to near-Earth objects (NEOs), and eventually to Mars. NASA is also exploring how the ISS elements and program infrastructure can be utilized to enable or enhance exploration.

Through the ISS program, NASA is leading a consortium of 15 nations and 5 space agencies from around the world in the pursuit of space-based research, discovery, exploration and human spaceflight. The International Partnership has proven to be essential in accomplishing NASA's and the nation's goals in space and will continue for missions beyond LEO and onto Mars.

QUESTION 3c:

If a decision is made to extend ISS operations, does NASA have a target in mind as to how long it would be extended?

ANSWER 3c:

NASA has not come to a recommendation on the lifetime of ISS. NASA, with its ISS International Partners, is undertaking a review of research and technology goals that would inform the required operational lifetime of ISS.

QUESTION 3d:

What is the status of discussions with international partners on a potential extension?

ANSWER 3d:

At the engineering management level, NASA and its partners have worked to identify the potential lifetime of ISS and determined it can be safely and effectively operated in the current configuration through 2028. As NASA has not come to its own internal recommendation on how long we need ISS to accomplish our objectives, we have not yet formally discussed ISS lifetime extension with our international partners at the Agency management level.

QUESTION 3e:

Further, if an ISS extension beyond 2020 is not certain, does pursuing the crew transportation system program, particularly if it is not fully funded in the FY 2014 Commerce, Justice, and Science Appropriations bill, make sense?

ANSWER 3e:

NASA is committed to procuring crew transportation and rescue services from one or more domestic, commercial providers, and the Agency supports Congress' reaffirmation in the NASA Authorization Act of 2010 (P.L. 111-267) that, "...NASA shall make use of United States commercially provided ISS crew transfer and crew rescue services to the maximum extent practicable." The Commercial Crew Program (CCP) aims to facilitate the development of a U.S. commercial crew space transportation capability in 2017, and full funding of the FY 2014 request is essential to restore a human spaceflight capability to the United States in this timeframe. Reduced funding will delay the operational availability of domestic commercial services, extending the period during which NASA will be solely reliant on international partners to provide crew transportation and rescue services to the ISS.

QUESTION 4:

NASA's Earth science programs represent a 71 percent contribution to the U.S. Global Change Research Program (USGCRP). Why is NASA's contribution important to the interagency USGCRP? Why is it important for NASA to be a leader in Earth sciences as it contributes to our nation's overall global change and climate science efforts?

ANSWER 4:

Natural and human-induced changes in the Earth system – from our planet's interior to the land surface, atmosphere and oceans – affect all aspects of life. If we are to understand and respond to those changes, we need a foundation of observations collected from the land, sea, air and space, integrated with models and other tools to develop the necessary information to make decisions. The Nation has invested significantly in developing this capability to conduct Earth science research within NASA. The Agency's Earth Science program represents a 55 percent contribution to the USGCRP and offers a unique view from space and the long-term data record necessary to support

the work of USGCRP. The NASA Earth Science program provides leadership to USGCRP by advancing our understanding of integrated Earth systems, including the global atmosphere, oceans and sea ice, land surfaces, ecosystems, and how these systems affect – and are affected by – humans. The NASA Earth Science program continues to lead the international science community in observing our home planet and understanding it through scientific research. The funding ensures that the United States can continue to lead the world in global-scale observations exploration of the integrated Earth system.

QUESTION 5:

What is the reason that only 1 percent (about $30M) of the $3B requested for the International Space Station program would be devoted to supporting fundamental biology and physical science research, a main use of the ISS?

ANSWER 5:

The National Academies' Decadal Survey provided NASA with over 60 "highest priority" research recommendations, and eight potential prioritization criteria. All of NASA's current ISS research portfolio is within the highest priority recommendations of the Decadal Survey. Within the limits of NASA's budget profile, the Agency will closely consider the recommendations of the Decadal Survey in decisions on investments in new research facilities and capabilities for the ISS, in a research program that balances the pursuit of significant new scientific discoveries and the construction of a foundation of knowledge that supports future human exploration missions.

Beyond being an unparalleled asset for scientific research, the ISS is a technology development and demonstration platform. As noted in the response to question #3, the ISS is currently being utilized to demonstrate advances in life support systems, robotics for crew support and spacecraft servicing, and space-durable materials. NASA is also funding technology development activities that will eventually be demonstrated onboard the ISS such as EVA systems, radiation monitoring, docking systems, and autonomous mission operations. These and other technology development activities are being driven in part by NASA's overall exploration goals to extend human presence beyond LEO to near-Earth objects (NEOs), and eventually to Mars. NASA is also exploring how the ISS elements and program infrastructure can be utilized to enable or enhance exploration.

QUESTION 5a:

What is the reason for having the ISS research budget support operations (strategic, tactical and operational support to all NASA payloads including the five international partners' research payloads, as well as maintenance, operation, and integration) when operations and maintenance for the ISS are already funded in a separate ISS budget line?

ANSWER 5a:

The development, integration and operations of ISS research represent unique challenges to the ISS program that are better served by managing to a specific budget line. A specific budget line provides stability in resources and expectations for out year integration and operations activities. This line item provides for personnel, facilities, test equipment, communication support, and payload processing that is unique to research activities.

QUESTION 6:

How likely is it that NASA will be able to secure operational commercial crew transportation services to the ISS by 2017? NASA still hasn't had an independent cost and schedule estimate carried out for the commercial crew development program. In addition, NASA's recently released Independent Cost Assessment only assessed the approach and methodology used for developing NASA's internal cost estimates. How is Congress to evaluate the credibility of the FY 2014 budget request for that program?

ANSWER 6:

NASA is committed to procuring crew transportation and rescue services from one or more domestic, commercial providers, and the Agency supports Congress' reaffirmation in the NASA Authorization Act of 2010 (P.L. 111-267) that, "...NASA shall make use of United States commercially provided ISS crew transfer and crew rescue services to the maximum extent practicable." The Commercial Crew Program (CCP) aims to facilitate the development of a U.S. commercial crew space transportation capability in 2017, and full funding of the FY 2014 request is essential to restore a human spaceflight capability to the United States in this timeframe. Reduced funding will delay the operational availability of domestic commercial services, extending the period during which NASA will be solely reliant on international partners to provide crew transportation and rescue services to the ISS.

Regarding the importance of receiving full funding for the Commercial Crew Program to enable the Agency to remain on track for a 2017 operational availability date, NASA is confident that, if Congress funds the program to the level requested in the FY 2014 budget, commercial crew transportation will be available in calendar year 2017. The commercial participants have stated that they could make services available before 2017.

QUESTION 7:

The Aerospace Safety Advisory Panel (ASAP) stated in its FY 2012 Annual report that: "NASA's continued retention of the SAA [Space Act Agreement] flight demo option raises questions in our minds about the government's safety obligations as well as how such an option would move NASA any closer to a certified system. It could also lead NASA down the slippery slope of being forced to curtail their certification program for NASA crewmembers merely because of a small number of possibly lucky, non-certified

flights. We do not understand the full implication of the optional approach and are concerned that it increases risk. "

a. Will all commercial crew program activities after the Commercial Crew Integrated Capability (CCiCap) baseline program be carried out under FAR based contracts?
b. If not, what specific activities would be done through other procurement means?

ANSWER 7:

NASA plans to use FAR-based contracts for the certification and purchase of the commercial crew services.

QUESTION 8:

Recently, you wrote a guest column for the Cleveland Plain Dealer. You stated "Seizing and isolating an asteroid not only fulfills our congressionally mandated obligation to "detect, track, catalogue and characterize" near-Earth objects, it will demonstrate our new deep-space technologies, move us closer to our goal of sending humans to Mars and enhance our ability to protect our planet and prevent natural disasters from space. "

In a recent briefing, Committee staff were told that the additional $20M for NEO detection and characterization would be used to select an appropriate asteroid to capture not to enhance the congressionally-mandated survey of detecting and characterizing near Earth objects 140 meters in diameter or larger.

Please clarify the primary purpose of the additional $20M request for NEO detection. With regards to the purpose of the new asteroid capture mission, how does it advance the nation's preparedness for asteroid mitigation as compared to investments that would focus directly on deflection of potentially hazardous near-Earth objects?

ANSWER 8:

To find suitable targets for this mission, the current asteroid observational campaign will be enhanced. The approach within the NASA NEOO Program in the President's FY 2014 budget request is to expand the existing NEO detection and characterization activities. This includes making available more time on existing ground-based observatories capable of detecting or characterizing NEOs, such as Pan-STARRS or the Space Surveillance Telescope (SST). These enhancements will simultaneously find the larger hazardous asteroids, and will continue beyond the target selection for this mission to extend detection and characterization by the observation program to include all sizes of asteroids. The asteroid retrieval initiative, and the vital precursor activities that will be necessary to ensure its success, will result in additional insight into the nature and composition of NEOs and will increase our capability to approach and interact with asteroids.

QUESTION 9:

The request for Earth sciences is being increased relative to that spent for the program in FY 2012. What is the rationale for the proposed increase and what activities would it fund? How will that the request for Earth sciences support the additional responsibilities proposed for the program in FY 2014, namely to develop climate sensors and to develop concepts for sustaining land imaging data?

ANSWER 9:

The FY 2014 budget request for Earth Science will enable NASA to continue working on innovative missions to observe natural and human-derived atmosphere processes, facilitate our understanding of long-term changes in the climate, and enable the more accurate forecasting of extreme weather systems. Continued funding for the NASA Earth Science program reflects an understanding and appreciation for the broader value of Earth observations for our Nation and our constituents. The requested funding will enable continued development and testing of applications, which combine the measurements and research-derived understanding into targeted information products that provide direct benefit to other mission agencies, private sector users, and indeed to all of society.

Specifically, FY 2014 funding for the NASA Earth Science program at the $1.846B level would help:

- Ensure the launch of four missions by the end of calendar year 2014, including the first Tier 1 decadal survey mission, Soil Moisture Active-Passive (SMAP). Measuring soil moisture and freeze-thaw cycling over the globe, SMAP will enable new advances in water cycle and climate science, as well as short-term forecasting. SMAP will lead to improved weather forecasts, flood and drought forecasts, and predictions of agricultural productivity and climate change, as well as to improved understanding of the sources and sinks of carbon. Additionally, in 2014, NASA will launch the Global Precipitation Measurement (GPM) mission, and the Orbiting Carbon Observatory (OCO)-2, and a refurbished Stratospheric Aerosols and Gas Experiment III (SAGE III) to the International Space Station.

- Expand the successful Venture-class competitive flight program, complete integration of two Earth observing instruments on the Deep Space Climate Observatory (DSCOVR), and provide $10M to fund research focused directly on providing the foundation for a useful and efficient Carbon Monitoring System.

- Funds initial studies, with the U.S. Geological Survey, for a new land imaging project for development of a national sustained Land Imaging Satellite System, to build on the success of the 41-year long data set made possible through the LandSat series of missions and NASA's recent launch of the NASA/USGS Landsat Data Continuity Mission.

- Continue the operation of the world's most extensive scientific data and information system for processing, archiving, and distributing Earth system data to ensure the widest possible use of the data.

QUESTION 9a:

Has the Administration informed you that it will submit a supplemental budget request to support these new responsibilities? If not, what work will be cut to accommodate these additional responsibilities?

ANSWER 9a:

The FY 2014 budget request already reflects these priorities and includes sufficient funding to continue current responsibilities as well as begin new responsibilities including:

- Initiate development of a climate sensor program for continuous monitoring of solar radiation, global ozone profiles, and Earth radiation balance, starting in the 2022 timeframe.
- Continue support for NASA's 7 missions that are in formulation and development for launch between 2016 and 2021, including the Gravity Recovery and Climate Experiment (GRACE) Follow-On gap-filler mission which contributes to drought and subsurface aquifer monitoring; the Surface Water Ocean Topography (SWOT) mission to provide first-ever wide-swath mapping of ocean eddies; the Cyclone Global Navigation Satellite System (CYGNSS) mission to measure the extreme wind speeds in the eyewalls of developing hurricanes and potentially leading to improved hurricane intensity forecasts; the Orbiting Carbon Observatory-3 which will fly on the International Space Station; the Tropospheric Emissions: Monitoring of Pollution (Tempo) instrument to measure air quality and pollution over greater North America and which will fly as an instrument on a commercial geostationary communications satellite; and the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) precision ice topography mission.
- Continue pre-formulation studies for the Pre-Aerosols, Carbon and Ecosystems (PACE) mission to measure global ocean color and productivity, the L-band Synthetic Aperture Radar, and other Decadal Survey-recommended and climate a

QUESTION 10:

How many NASA education grantees or contractors will be affected as a result of the proposed consolidation? How have they been informed of these proposed changes?

ANSWER 10:

NASA's Office of Education remains responsible for coordinating NASA's education efforts under the Administration's proposal. NASA's education team at Headquarters and the Centers is made up of education personnel with a long history of implementing

space-related education content. It includes staff with expertise in academic teaching, informal education, K-12 instruction and supervision, grant management, program/project management, and STEM expertise. Additionally, many of NASA's education activities are implemented by grantees or cooperative agreement partners in universities, school districts and informal education institutions across the Nation. The exact number of education grantees or contractors affected as a result of the proposed consolidation is still to be determined. NASA has held a number of briefings and discussions with its workforce and external partners on the proposed FY 2014 strategy. Content and efforts that are no longer funded by NASA will be reviewed by the National Science Foundation, Department of Education and the Smithsonian Institution. Elements or activities that support the STEM consolidation goals will be considered for incorporation into the broader STEM consolidation efforts.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"An Overview of the National Aeronautics and Space Administration
Budget for Fiscal Year 2014"
Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)
Questions submitted by Rep. Dana Rohrabacher, Vice-Chairman, Committee on Science, Space, and Technology

QUESTION 1:

As a customer, NASA has chosen to spend significant funds toward the development of technologies in pursuit of competing Commercial Crew systems to meet NASA's transportation requirements to Low Earth Orbit. How much has NASA spent with each of the competing companies, and how much have the companies spent themselves toward these technology development and demonstration efforts?

ANSWER 1:

Through the end of April 2013, NASA had paid $838.9M to its commercial partners for milestones completed under the CCDev1, CCDev2, and CCiCap Space Act Agreements, as detailed in the table below. Information on the total dollars spent by the companies toward these technology development and demonstration activities is proprietary and would need to be obtained directly from those companies.

	Sierra Nevada Corp.	Boeing	Blue Origin	Paragon	United Launch Alliance	SpaceX	Total
Total Payments to Providers for the Commercial Crew Program (CCP) in $M	212.6	352.5	25.7	1.4	6.7	240.0	838.9
CCDEV1 (Space Act Agreements only)	20.0	18.0	3.7	1.4	6.7	-	49.8
CCDEV2 (Space Act Agreements only)	97.6	112.9	22.0	-	-	75.0	307.5
CCiCap (Space Act Agreements only)	95.0	221.6	-	-	-	165.0	481.6

QUESTION 2:

What is NASA's estimate for the costs required to develop and demonstrate those technologies in-house at NASA through standard procurement processes?

ANSWER 2:

In early 2011, an estimate of possible costs for several potential designs of a crew transportation system was developed by NASA using NASA/Air Force Cost Model (NAFCOM), reflecting a traditional development approach. The estimates for each option assumed a Demonstration Phase over FY 2011-2015 and included three demonstration flights. The system with the highest estimated development cost was approximately $10.8B (70 percent confidence level). The system with the lowest estimated development cost was approximately $7.7B (70 percent confidence level).

QUESTION 3:

There are several different vehicle architectures and different technologies expected to be proposed for the ultimate Commercial Crew systems. What part will these differences play in NASA's selection process as we move forward toward certification? What other criteria will NASA use in the selection process?

ANSWER 3:

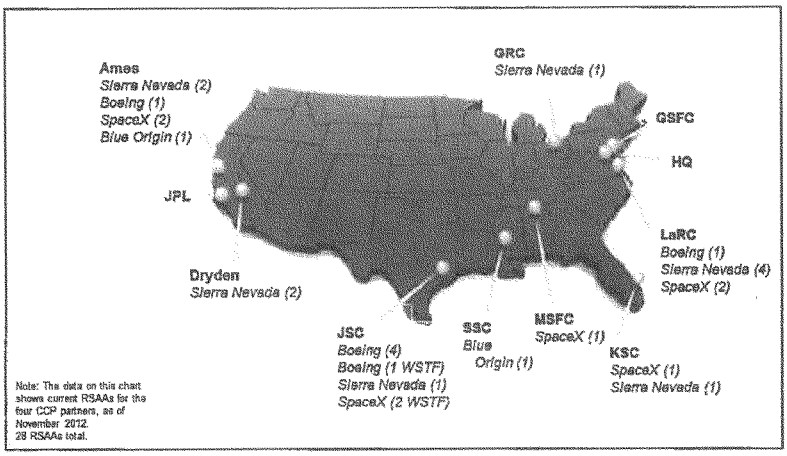
NASA published its draft evaluation criteria for the next phase of the Commercial Crew Program in July in a draft Request for Proposals, which can be accessed online. The final RFP with the official evaluation criteria is planned to be released in October.

QUESTION 4:

It is my understanding that the Commercial Crew competitors are working closely with NASA teams, both to exchange expertise and to facilitate the certification process. Does this close working relationship extend to the expertise of NASA Centers in the development of their vehicles? Can you give some examples?

ANSWER 4:

Yes, expertise, resources, and infrastructure from almost every NASA Center are being engaged to assist the commercial crew partners in their development efforts. One avenue for exchange is through the use of Reimbursable Space Act Agreements (RSAAs) with specific NASA Centers for expertise and/or infrastructure support for things such as wind tunnel testing, operations training, and test stand utilization. As the end of the 2012, there were 28 active RSAAs with NASA's commercial crew partners. See graphic below.



QUESTION 5:

Some of the Commercial Crew vehicles are capsules designed to land in the ocean. Does this design increase the cost of the system due to the difficult and potentially dangerous recovery? Does this impact the reusability of the systems, and how does that impact cost?

ANSWER 5:

Specific landing architectures are unique to each crew transportation system. Landing on land versus in the ocean can be either beneficial to the overall cost and complexity or not, depending on the system design. Land landing is not superior or inferior than water landing in all circumstances. Regarding reusability, in general, reusable systems are more expensive to develop but can be less expensive to operate than expendable systems. But, again, it depends on the specific system design and architecture.

QUESTION 6:

The proposed new asteroid capture, relocation, and rendezvous mission includes a $20M addition for asteroid search. This would double the asteroid search budget, but this new money would only be used to locate asteroids less than 10 meters – which pose no threat to life or property on Earth. This means that by doubling the budget, we would not get one step closer to accomplishing the requirement currently in law to identify dangerous asteroids - a mission that you have said cannot be accomplished on time with the expected funding level. With resources so thin, wouldn't this funding be better used to accomplish your current mission instead of creating a new mission to find, capture, and tow a small asteroid to the Moon - an asteroid that, according to NASA, is too small to be a threat to Earth, is not scientifically interesting, and does not have useful resources?

ANSWER 6:

The $20M of additional funding will be used to enhance our capabilities to find and characterize all sizes of near Earth asteroids, both hazardous to the Earth and suitable Asteroid Redirect Mission targets. The asteroid initiative will benefit both our planetary exploration and planetary defense goals.

QUESTION 7:

FOLLOW-UP: In light of the fact that; again, according to NASA, a demonstration of the Exploration technologies and capabilities needed for future missions to the ultimate destination of Mars does not require an asteroid at the Moon, what can you add or clarify that would convince Congress to approve a potential $2.5B program to capture and move such an asteroid?

ANSWER 7:

The overall mission is composed of three separate and independently compelling elements: the detection and characterization of candidate near-Earth asteroids; the robotic rendezvous, capture, and redirection of a target asteroid to the Earth-Moon system; and the crewed mission to explore and sample the captured asteroid using the Space Launch System (SLS) and the Orion crew capsule. The mission integrates a variety of technologies and capabilities important to future crewed missions to Mars and other deep space destinations. These include the acceleration of high power solar electric propulsion development; which has future science mission, commercial, and human exploration applications; and rendezvous with and maneuver of a non-cooperative target in deep space, which is enabling for missions to other deep space destinations, such as a mission to Phobos. In addition, this mission represents an unprecedented technological challenge -- raising the bar for human exploration and discovery, while helping protect our home planet and bringing us closer to a human mission to Mars in the 2030s. Each mission element will heavily leverage on-going activities in Space Technology, Science, and Human Exploration and Operations.

Assumptions on implementation approach and the asteroid capture process drove cost estimates for the Keck study concept. NASA is using a set of reference Level 1 requirements for the current concept study to determine technical and programmatic feasibility. This set includes technical performance requirements and a cost cap requirement, which provides flexibility to manage cost and risk as part of the effort. NASA's goal is to develop and implement the robotic asteroid redirect mission for well under the Keck team's $2.6B estimate. The original Keck study cost estimate and the initial NASA analysis and cost estimates both examined the robotic redirect mission element and related mission operations, and neither included the crew exploration and sampling segment of the mission. The Keck study included the cost of the launch vehicle, while NASA estimates will address the cost of the launch vehicle separately from the rest of the robotic redirect mission element, as the vehicle choice follows mission definition. In addition to the concept currently under analysis, we are also

looking at other mechanisms and mission systems, including a planned external call for ideas and discussions with potential U.S. and international partners. NASA is committed to finding a concept that is both technically and programmatically feasible. The actual cost will be reflected in future budget submits.

A crewed mission to an asteroid in the lunar vicinity complements the activities on the ISS to provide capabilities and risk reduction for human missions to Mars. NASA's Human Research Program (HRP) uses the ISS to investigate and mitigate the highest risks to human health and performance, providing essential countermeasures and technologies for human space exploration. As a technology development and demonstration platform for exploration, the ISS is currently being utilized to demonstrate advances in life support systems, robotics for crew support and spacecraft servicing, and space-durable materials. NASA is also funding technology development activities that will eventually be demonstrated onboard the ISS such as EVA systems, radiation monitoring, docking systems, and autonomous mission operations. With the Asteroid Redirect Mission, NASA will gain operational experience in the deep space radiation environment with the character/composition of the radiation inside the Orion vehicle, but without the dangerous levels of exposure projected for long duration (> 6 months) trips. The crewed mission to the asteroid would enhance current test objectives for early flights of SLS and Orion to provide important additional experience in human spaceflight applicable beyond Earth orbit toward the ultimate goal of a crewed mission to Mars. The round-trip missions over greater than 20 days to the asteroid will include highly limited resources and no ability to quickly return/abort to Earth coupled with operation of the Orion crew vehicle during missions to encounter and sample the asteroid. The complex trajectories in the trip to the asteroid in a distant retrograde orbit around the Moon; rendezvous and proximity operations using the Orion spacecraft in deep-space environments; deep-space operations such as guidance, navigation and control nine days away from Earth; EVAs to explore the asteroid, and extraction, management; and return of samples in the Orion will all be challenging and inspirational early operations beyond Earth orbit that retire significant risk in preparation for future Mars missions. This learning will help us design the additional habitat and related systems needed for future deep space missions.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
"An Overview of the National Aeronautics and Space Administration
Budget for Fiscal Year 2014"
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:

During the NASA budget briefing provided by NASA's Deputy CFO, Andrew Hunter, he told Congress that, though the Agency does not have a cost figure, or even cost estimate on how much the Administration's asteroid lasso mission will cost, he assured us that it will be less than the estimate provided by California Institute of Technology's Keck Institute for Space Studies. NASA' Associate Administrator for Human Exploration, Bill Gerstenmaier informed an audience the same thing during a briefing on the asteroid mission a few weeks ago. So NASA admits they don't know how much the asteroid mission is going to cost, but you are sure that it won't be as much as the Keck Institute said it would be. If you don't have a total cost figure, or even a general "guestimate", how do you know it will be lower than Keck Institute's estimate? How much less?

ANSWER 1:

The Keck Institute for Space Studies concept included cost for an entire spacecraft development under very conservative implementation assumptions. This Keck cost analysis was conducted quickly with many assumptions. NASA's strategy for an asteroid redirect mission is to leverage ongoing activities, which individually provide technology advancements or new capabilities for human exploration, science and commercial applications. We plan to leverage technology advancements and flight demonstration plans for advanced high power solar electric propulsion technology. We will also add a capture mechanism.

In addition, the Keck study concept included conservative top-level design assumptions for the spacecraft capture concept, including loads during capture and interfaces. The current concept results from more detailed mission and systems analysis. Our concept studies have included physics-based simulations, which show the assumptions used the Keck study to be conservative.

These assumptions drove cost estimates for the Keck study concept. NASA is using a set of reference Level 1 requirements for the current concept study to determine technical and programmatic feasibility. This set includes technical performance requirements and a cost cap requirement, which provides flexibility to manage cost and risk as part of the effort. NASA's goal is to develop and implement the robotic asteroid redirect mission for well under the Keck team's $2.6B estimate. The original Keck study cost estimate and the initial NASA analysis and cost estimates both examined the robotic redirect mission element and related mission operations, and neither included the crew exploration and sampling segment of the mission. The Keck study included the cost of

the launch vehicle, while NASA estimates will address the cost of the launch vehicle separately from the rest of the robotic redirect mission element, as the vehicle choice follows mission definition. In addition to the concept currently under analysis, we are also looking at other mechanisms and mission systems, including a planned external call for ideas and discussions with potential U.S. and international partners. NASA is committed to finding a concept that is both technically and programmatically feasible.

QUESTION 2:

I am informed NASA recently executed a Space Act Agreement with Bigelow Aerospace. Page one of the Agreement lists as one of Bigelow's "long-term plans ... to place a lunar base on the surface of the Moon". That objective is in agreement with my bipartisan legislation, the REAL Space Act which I introduced a few weeks ago along, with 8 cosponsors and directs NASA to return to the Moon by 2022. I'm excited to see NASA exploring a lunar base and investigating private sector opportunities for the SLS. Could you tell us more about what NASA is doing to support this agreement?"

ANSWER 2:

In March 2013, NASA signed a Space Act Agreement (SAA) with Bigelow Aerospace to study possible commercial applications for beyond-low-Earth-orbit (beyond-LEO) human spaceflight activities. In the future, there may be opportunities for joint Government-commercial activities beyond LEO, and the study, which is being done in two parts, is intended to survey current beyond low earth orbit private sector spaceflight-related goals and objectives and then outline specific potential assets/capabilities in the private sector. The study is not specifically focused on, or limited to, a lunar facility.

Specifically the two deliverables/gates are defined as:

Gate 1: Conduct a joint formulation of objectives for the commercial and government contributions and utilization for the development and exploration of space beyond low Earth orbit.

Gate 2: Assess the intersection of the capability to live and work in low Earth orbit with other commercial interests in low earth orbit and all of cislunar space, including specific commercial proposals and interests towards those ends.

QUESTION 3:

I understand that NASA is not flying a manned Orion mission until 2021. You're planning two initial test flights in 2014 and in 2017. What specifically can NASA do to accelerate that first manned Orion mission?

ANSWER 3:

The uncrewed Exploration Flight Test-1 (EFT-1) (slated for 2014) and Exploration Mission-1 (slated for 2017) are constrained by manufacturing capacity; additional funding would not accelerate these planned milestones. NASA will continually re-evaluate the projected 2021 launch date of the crewed Exploration Mission-2 over the next few years to assess the potential for the integrated Orion, Space Launch System, and Ground Systems capabilities to support an earlier launch opportunity.

QUESTION 4:

We understand that NASA has encountered some problems with Education and Public Outreach activities as a result of the sequester, but rather than eliminating duplication, NASA is cutting back on that outreach.

For example, NASA has an Office of Communications, so why does the Human Spaceflight Mission Directorate also have its own Outreach budget? Why does the new Technology Mission Directorate have their own Outreach activities? It seems that there are duplicate communications activities.

Besides being less effective, duplication is more costly too. We would like to hear how NASA might consolidate these separate communications functions, similar to how NASA has consolidated the various NASA STEM education efforts, in order to more effectively communicate NASA's benefits to the American people, and in a way that is more transparent and accountable to this Congress?

ANSWER 4:

To approach NASA communications activities more strategically, the Communications Coordinating Council (CCC) includes cross-cutting senior representatives of the communications and outreach organizations from the mission directorates, projects and programs, and communications. This council has authority and accountability for all of NASA's public communications strategy and implementation, and serves as the Agency's senior decision-making body for strategic direction, planning and implementation of all communications programs, events and activities.

Specifically, the CCC ensures a coordinated and sustainable process to deliver timely information to NASA's employees, the public and other stakeholders, and facilitates coordination, fosters collaboration, and ensures effective use of resources in order to eliminate redundancy in all communications activities, and execute NASA's outreach activities more strategically, responsibly and efficiently.

NASA supports a robust public outreach effort that recognizes the importance of disseminating information, informing and educating a variety of external audiences, and inspiring new generations of explorers. As a result of Sequestration and a significantly reduced funding level for FY 2013, the Agency implemented a review of all public

outreach efforts whose goal is to reach out to external and internal stakeholders and the public concerning NASA, its programs, and activities. Given the significant financial constraints, it was prudent for the Agency to review expenditures that were not directly related to mission safety, operations, and development.

To date, the Office of Communications, in coordination with the Agency's Communications Coordinating Council (CCC), has reviewed and approved 650 internal and external outreach activities that date from March 23 through the end of the fiscal year.

Appendix II

Additional Material for the Record

SUBMITTED STATEMENT BY REPRESENTATIVE EDDIE BERNICE JOHNSON
RANKING MEMBER, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
U.S. HOUSE OF REPRESENTATIVES

Good afternoon. I want to welcome NASA Administrator Bolden back to the Committee, and I look forward to his testimony regarding NASA's Fiscal Year 2014 budget request.

As you know, last week, the full Science, Space, and Technology Committee heard from Dr. John Holdren, the President's Science Advisor and Director of the White House Office of Science and Technology Policy. He described the President's budget request for R&D as one that recognizes the "profound importance of continued progress in science and technology even as we work to reduce budget deficits and hold the line on government spending." I could not agree more. A commitment to deficit reduction should not negate the need to invest in our future.

And I consider NASA and its programs to be one of the most strategic of the investments we can make as a nation. Not only is NASA an engine of innovation for America, but it has an additional feature that sets it apart from much of the rest of the federal R&D enterprise—namely, its ability to inspire. That quality of inspiration not only sets NASA apart, but it has also helped to make NASA one of the most positive symbols of our nation, recognizable throughout the world.

We need that inspiration, now more than ever, as we seek to encourage our young people to pursue careers in science and engineering. Because it is that inspiration that breathes life into STEM education initiatives and helps the STEM curricula motivate a diverse cross-section of our youth, including those who have traditionally been under-represented in the STEM fields. That is one of the reasons I told Dr. Holdren that I need to know more about the Administration's proposed reorganization of federal STEM programs before I can make an informed assessment of the proposed changes. NASA's STEM initiatives and educational outreach, particularly through its science missions, have long been able to excite our young people, and I don't want to lose that excitement.

Ultimately, though, it is the challenging work that NASA undertakes that makes it such a crown jewel of our nation's R&D enterprise. Yet, as a recent report by the National Academies makes clear, "NASA cannot execute a robust, balanced aeronautics and space program given the current budget constraints." That finding should not be a surprise to anyone who has been on this Committee for more than a few years. We—successive Administrations and Congresses alike—have asked NASA to carry out many important tasks, but too often we have allowed short-term fiscal pressures to overrule the strategic imperative to invest in NASA at levels that are commensurate with those tasks.

I hope as we prepare to reauthorize NASA this year, that we see investing in NASA not as a discretionary luxury, but rather as what it is—a critical investment in the future well-being of this nation and a beacon of inspiration for the generation that will be coming along to create the jobs of the future, explore the unknown, and improve the quality of life back here on Earth.

SUBMITTED LETTER BY THE PLANETARY SOCIETY

THE PLANETARY SOCIETY

PLANETARY.ORG

65 SOUTH GRAND AVENUE
PASADENA, CA 91105 USA
PHONE: (626) 793-5100
FAX: (626) 793-5528

April 24th, 2013

The Honorable Steven Palazzo
Chairman, Subcommittee on Space and Aeronautics
Committee on Science, Space and Technology
U.S. House of Representatives
2321 Rayburn House Office Building
Washington, DC 20515

The Honorable Donna Edwards
Ranking Member, Subcommittee on Space and Aeronautics
Committee on Science, Space, and Technology
U.S. House of Representatives
394 Ford House Office Building
Washington, DC 20515

Dear Chairman Palazzo and Raking Member Edwards,

The Planetary Society has deep concerns about the continued effort to defund Planetary Science in NASA's 2014 budget proposal. The budget ignores Congress's rejection of similar cuts proposed in FY13 as well as the public's strong support of this highly effective part of NASA. The proposed cut threatens U.S. leadership in deep space exploration and planetary research, and it creates negative long-term technological and engineering consequences for the aerospace industry. Without immediate investment in technology and mission development – not possible under the FY14 proposal – the United States will go "radio dark" in almost all regions of the solar system by the end of the decade.

On August 6th of last year, millions of people around the world watched as NASA's Curiosity rover landed on Mars. It was NASA's greatest – and most visible – triumph in years; the result of a decade's worth of steady investment in planetary exploration. Curiosity captured the public's imagination, becoming the "Apollo moment" for a new generation of Americans by inspiring countless numbers to pursue careers in science, math, engineering, and related fields.

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85 SOUTH GRAND AVENUE
PASADENA, CA 91105 USA
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But the FY14 budget does not support the robust investment in Mars exploration required for there to be any more "Curiosity moments." NASA was able to assemble a new mission for 2020 that duplicates the design of the Curiosity rover, but there are no longer the resources for long-term technology development to create the next generation of missions to the Red Planet. It is not clear whether the 2020 Rover will follow recommendations of the National Research Council's Planetary Science Decadal Survey and cache samples of Mars to be returned to Earth in the future. The FY14 budget and its projection ensure a moribund future for our Mars program.

The proposed budget for FY14, $1.217 billion, represents the latest in a multi-year effort to underfund Planetary Science within NASA [fig 1]. Though this number looks larger than was projected in FY13, there are important caveats to consider. Included in FY14 are two new requests to the program: $50 million for Pu-238 production previously located in the DOE budget, and $20 million for near-Earth object (NEO) detection in service of the asteroid retrieval mission. While both of these are important, we must consider $1.147 billion to be the "true" number when comparing to last year's appropriation. As such, FY14 represents a $268 million cut from levels approved by Congress in FY13 (before sequestration and rescission).

The FY14 budget also ignores the $75 million approved by Congress in FY13 to begin formulation activities for a mission to Jupiter's moon Europa and dismisses any possibility of a mission in the near future. We urge Congress to provide continued funding for a Europa mission and to encourage NASA and the Administration to commit to this popular, scientifically important project.

The Planetary Society would like to highlight one positive aspect of the FY14 budget, which is that proper funding is requested to restart Plutonium-238 (Pu-238) development. Pu-238 is a power source for spacecraft that cannot

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use solar panels, such as missions to deep space or to targets bathed in shadow. The United States stopped producing Pu-238 in the late 1980s and our supply is now at critical levels. It takes many years to generate usable plutonium, and we strongly encourage Congress to fund its development as requested to prevent future shortages.

In difficult economic times, The Planetary Society recommends that Congress prioritize the effective and productive Planetary Science Division within NASA and fund it at $1.5 billion per year. This is a modest increase above the request and represents less than 9% of NASA's total budget while supporting an extremely successful part of the agency. According to our analysis, this level is the minimum necessary to support a balanced program that follows the recommendations contained within the NRC's Planetary Science Decadal Survey, which includes a flagship mission to Europa.

NASA is one of the great scientific and cultural institutions of the United States. It has the unique responsibility of inspiring the public through unprecedented achievements in human and robotic exploration into the depths of space. Decades of strong, bipartisan support of NASA have created the world's leading engineering and scientific space agency. In challenging economic times, we encourage Congress to support the part of NASA that has consistently delivered on its promises: Planetary Science.

Sincerely,

Bill Nye
Chief Executive Officer
The Planetary Society

THE PLANETARY SOCIETY
PLANETARY.ORG

85 SOUTH GRAND AVENUE
PASADENA, CA 91105 USA
PHONE: (626) 793-5100
FAX: (626) 793-5528

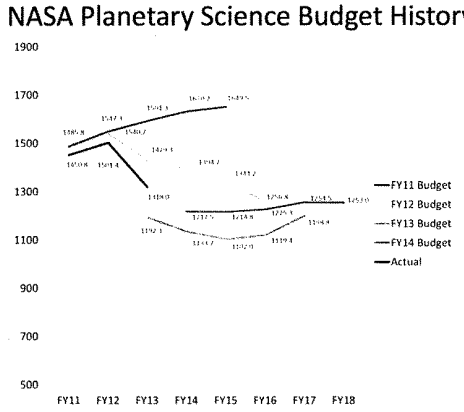

Fig 1: Comparison of the budget projections for Planetary Science (in millions of dollars) over the past four years. Note that the "Actual" line assumes an even application of the sequester and rescission for FY13 and the FY14 budget includes the new funding for Pu-238 and NEO detection.