S. HRG. 112–506

# REALIZING NASA'S POTENTIAL: PROGRAMMATIC CHALLENGES IN THE 21ST CENTURY

## HEARING

BEFORE THE

## COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

MARCH 15, 2011

Printed for the use of the Committee on Commerce, Science, and Transportation

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

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APPENDIX

# REALIZING NASA'S POTENTIAL: PROGRAMMATIC CHALLENGES IN THE 21ST CENTURY

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**TUESDAY, MARCH 15, 2011**

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
*Washington, DC.*

The Committee met, pursuant to notice, at 2:35 p.m. in room SR–253, Russell Senate Office Building, Hon. Bill Nelson, presiding.

## OPENING STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM FLORIDA

Senator NELSON. Good afternoon. The meeting will come to order.

I'm going to dispense with an opening statement, and I want to call on Senator Hutchison to make a statement.

I do want to say that Doug Cooke has led NASA's exploration initiatives for over 2 years, and he is going to retire. And this is going to be a significant loss. Your dedication throughout your distinguished career of over 37 years has been very evident in the roles that you have had, from defining the Space Shuttle entry flight-test program, advising the Columbia Accident Investigation Board, serving as deputy manager of the International Space Station, and, most recently, the role that you have now as Associate Administrator of the Exploration Systems Mission Directorate. And I want you to know how much we are appreciative of the extraordinary service that you've given, upwards of four decades, to your country and to America's space program.

So, Mr. Cooke, we'll miss you, but I'm sure we'll continue to see you. And we will continue to seek your advice and counsel.

Senator Hutchison.

## STATEMENT OF HON. KAY BAILEY HUTCHISON, U.S. SENATOR FROM TEXAS

Senator HUTCHISON. Thank you, Mr. Chairman. I appreciate very much all of the work that you do, collectively.

I have been working with the Chairman, now, for the last couple of years to have a plan for NASA, going forward, that we believe protects NASA's mission and is a balanced program that invests in the commercial sector, but has an emphasis on the NASA mission being accomplished, and being sure that it will be accomplished.

I am pretty critical—and the Chairman has been, as well—of the last 2 years' budget requests from the administration. Part of the concern is that there is a sudden change in direction, and there is concern that the senior leadership of the agency remains uncommitted to the full, faithful, and timely implementation of the law that we worked very hard to pass last year when we saw the budget submission from 2 years ago—well, from, actually, the beginning of this year. It—no, the beginning of last year, I guess. It is the law and it isn't an advisory framework.

When we wrote the NASA Reauthorization Act of 2010, this committee provided a balanced portfolio for NASA, with robust investment in science, research and development activities, and the continuation of human spaceflight and exploration development. The law prioritizes the continuation of work on the Orion crew exploration vehicle and redirects the agency's efforts to develop a heavy launch vehicle to carry Orion beyond low-Earth orbit.

To meet these requirements, we directed the Administrator to use as much existing technology as possible from the Shuttle and Constellation programs to shorten the development timeline, reduce costs, and maximize the use of taxpayer funds that have already been dedicated to our human spaceflight program. In carrying out that effort, the Administrator is directed to modify and extend existing contracts for the relevant technology to get started quickly, and to prevent the loss of critical skills and infrastructure.

Yet, 5 months have passed since the law's passage and we're still waiting for signs that the agency will comply with these directions. To my knowledge, not one major contract has been modified in furtherance of the requirements of the law that was passed by Congress and signed by the President. In fact, Mr. Chairman, a final report was due from NASA, 2 months ago, outlining its plans for the capsule and the heavy-lift vehicle, including related contract modification determinations. What we received was a preliminary report lacking much of the information required by the law. And now, 2 months later, we're still waiting for compliance with even this modest reporting requirement.

With these requirements still unresolved, we now must consider the President's FY 2012 budget request. Once again, the request appears to ignore many of the priorities that the law has established for human spaceflight. Specifically, the request reduces the funding for the Orion capsule and the heavy-lift vehicle by more than $1.3 billion below what we authorized for FY 12. At the same time, the request proposes a significant increase to the very same areas prioritized in the administration's last budget request, which Congress rejected.

The NASA Reauthorization Act was designed to promote investment in commercial crew capabilities while prioritizing the rapid development of a national launch system to resume exploration. This will allow us to develop an important backup capability along the way to fully develop a launch system for exploration, and it assures access to low-Earth orbit from a domestic source, should a commercial crew provider fail to provide reliable and safe capability.

The fact that this budget request that is before us today dramatically reduces funding for the heavy-lift launch vehicle and Orion

capsule while proposing a 70-percent increase for commercial crew is another illustration that the administration is not taking the steps necessary to embrace the priorities we established, and implement the law.

I have similar concerns with the budget request provisions related to space technology. Last year, we rejected the notion that we would invest in technology for the sake of doing so. We determined that we would not support investment in undisciplined research that was not closely tied to a specific mission. Yet, the budget request would transfer significant funding from exploration technology development, which is mission-specific, critical, and defined, to the general space technology line that has much less discipline. Taken together, the commercial crew funding and space technology proposals in this budget request bear an unmistakable resemblance to last year's budget request. The outline the President put forward was rejected, but now it seems to be coming back in another form.

Mr. Chairman, I don't want to see another year pass, where we don't have the focus that Congress passed and the President signed. So, I do hope that you can help us see that perhaps we're mistaken, that perhaps you are not going back to focusing just on the commercial side and leaving our basic NASA missions without the priority that Congress has put on the agency. We're here to make sure that NASA is strong and that America's place in the world, in space exploration, is preeminent. That is our goal. I think it's our common goal, but I don't think that we are in sync on how we get there.

Thank you, Mr. Chairman.

Senator NELSON. Senator, you're exactly right, that January report was entirely inadequate.

The Senator from Arkansas is the new Ranking Member on Science and Space Subcommittee.

I want to welcome you. Did you want to have any opening comments?

Senator BOOZMAN. Yes, sir, if it's appropriate.

Senator NELSON. OK. If you can truncate it, and then we'll get right on in. But, please.

## STATEMENT OF HON. JOHN BOOZMAN, U.S. SENATOR FROM ARKANSAS

Senator BOOZMAN. Thank you, Mr. Chairman. I'm pleased to be serving as the Ranking Member of the Science and Space Subcommittee. I look forward to working with you, Chairman Nelson and Chairman Rockefeller and our full-committee Ranking Member, Senator Hutchison.

I want to welcome the witnesses. Certainly, you all are so accomplished. You represent thousands of NASA professionals across the country who are working hard and innovating, every day. And we certainly look forward to your testimony.

Last year, Congress received a budget request for NASA that started a lengthy conversation among Members of Congress, the administration, and many stakeholders. At the end of this process, Congress overwhelmingly passed a bill, with more than 400 votes between the two chambers, and the President signed it last fall.

The new law provides a balanced set of activities for NASA to utilize the world-class skills and expertise of its work force. This includes significant investment in science, technology development, and the continuation of our human spaceflight activities, including the use of the International Space Station, which is now complete. The law also redirects activities related to our exploration program, where we have had challenges for a long time in developing a follow-on to the Space Shuttle.

I believe we need to bear in mind a few points as we consider the President's budget request for Fiscal Year 2012.

First, we should take a closer look at areas where the administration proposes significant deviations from the law. There's not been a significant passage of time between the passage of the law and the current request. The administration needs to, therefore, justify deviations from what Congress directed. Simple differences of opinion on policy are not enough. We must understand why the administration now proposes that we reprioritize funding to items like commercial crew transportation and space technology and away from the rocket and capsule that will allow us to resume the Nation's legacy as explorers.

Congress made many of these choices and decisions last year. We need to know what has changed in the last 5 months to prompt the budget request's alternative focus, counter to the clear direction of the new law.

Second, if NASA's budget will be reduced, like many other agencies, we need to fully analyze opportunities to limit overlap or duplication with other agencies to reduce some of these expenditures.

Third, we must carefully consider our investment priorities for NASA and how those affect our national defense and economic security needs.

America's preeminence in space is more than a source of national pride. It is a source of strategic advantage. We need to ensure that our investment preserves our intellectual and physical infrastructure, at a time where other nations, including China, are investing heavily to close the gap with us.

Finally, the programs at NASA must be executable and sustainable. NASA's history is rich with major breakthroughs and breathtaking achievements. The recent history, however, is also rich with examples of cost overruns, development delays, and poor technical choices. We no longer have the luxury of spending money on ships that never fly and satellites that never reach orbit. NASA must change some of its practices with respect to contracting and procurement. Its programs must focus on accomplishments that directly advance current mission objectives. Focused research and development is a key to operating in a constrained budget environment.

And with that, I yield back.

Thank you, Mr. Chairman.

Senator NELSON. Thank you, Senator.

OK. We've got all the Associate Administrators of NASA here. We want to get right into the nuts and bolts of what the budget should be for this agency, given the environment.

[The prepared statement of the Administrator follows:]

PREPARED STATEMENT OF HON. CHARLES F. BOLDEN, JR., ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Committee, I appreciate the opportunity to submit this statement for the record as part of the Committee's hearing today entitled *Realizing NASA's Potential: Programmatic Challenges in the 21st Century.* I want to thank you and all the Members of the Committee for the longstanding support that you have given to NASA. These are exciting and dynamic times for NASA. The challenges ahead are significant, but so are the opportunities we have to achieve big things that will create a measurable impact on our economy, our world, and our way of life.

The President's FY 2012 budget request of $18.7 billion for NASA continues the Agency's focus on a reinvigorated path of innovation and technological discovery leading to an array of challenging destinations and missions that increases our knowledge, develop technologies to improve life, to expand our presence in space for knowledge and commerce, and that will engage the public. With the President's signing of the NASA Authorization Act of 2010 (P.L. 111–267) on October 11, 2010, NASA has a clear direction and is moving forward. NASA appreciates the significant effort that advanced this important bipartisan legislation, particularly efforts by the leadership and Members of this Committee. This is a time of opportunity for NASA to shape a promising future for the Nation's space program.

Because these are tough fiscal times, tough choices had to be made. But the proposed FY 2012 budget funds all major elements of the Authorization Act, supporting a diverse portfolio of programs, while making difficult choices to fund key priorities and reduce other areas in order to invest in the future. A chart summarizing the President's FY 2012 budget request for NASA is enclosed as Enclosure 1.

We have an incredible balance of human space flight, science, aeronautics and technology development. Within the human space flight arena, our foremost priority is our current human spaceflight endeavor—the International Space Station—and the safety and viability of the astronauts aboard it. The request also maintains a strong commitment to human spaceflight beyond low Earth orbit. It establishes critical priorities and invests in the technologies and excellent science, aeronautics research, and education programs that will help us win the future. The request supports an aggressive launch rate over the next two years with about 40 U.S. and international missions to the ISS, for science, and to support other agencies.

At its core, NASA's mission remains fundamentally the same as it always has been and supports our new vision: *"To reach for new heights and reveal the unknown so that what we do and learn will benefit all humankind."* This statement is from the new multi-year 2011 NASA Strategic Plan accompanying the FY 2012 budget request, which all of NASA's Mission Directorates, Mission Support Offices and Centers helped to develop, and encapsulates in broad terms the very reason for NASA's existence and everything that the American public expects from its space program. Just last week, we completed the Space Shuttle Discovery's STS–133 mission, one of the final three shuttle flights to the International Space Station. Discovery delivered a robotic crewmember, Robonaut-2 (R2), and supplies that will support the station's scientific research and technology demonstrations. We recently made some preliminary announcements about program offices to carry out our future work. And we plan to release three additional high-priority solicitations spanning Space Technology's strategic investment areas. NASA brings good jobs and bolsters the economy in communities across the Nation. Our space program continues to venture in ways that will have long-term benefits, and there are many more milestones in the very near term.

Our human spaceflight priorities in the FY 2012 budget request are to:

- safely fly the last Space Shuttle flights this year and maintain safe access for humans to low-Earth orbit as we fully utilize the International Space Station;
- facilitate safe, reliable, and cost-effective U.S.-provided commercial access to low-Earth orbit first for cargo and then for crew as quickly as possible;
- begin to lay the ground work for expanding human presence into deep space—the Moon, asteroids, eventually Mars—through development of a powerful heavy-lift rocket and multi-purpose crew capsule; and
- pursue technology development that is needed to carry humans farther into the solar system. Taken together, these human spaceflight initiatives will enable America to retain its position as a leader in space exploration for generations to come.

At the same time, we will extend our reach with robots and scientific observatories to expand our knowledge of the universe beyond our own planet. We will

continue the vital work to expand our abilities to observe our planet Earth and make that data available for decision makers. We will also continue our groundbreaking research into the next generation of aviation technologies. Finally, we will make the most of all of NASA's technological breakthroughs to improve life here at home.

With the FY 2012 budget, NASA will carry out research, technology and innovation programs that support long-term job growth and economic competitiveness and build upon our Nation's position as a technology leader. We will educate the next generation of technology leaders through vital programs in science, technology, engineering, and mathematics education. And we will build the future through those investments in American industry to create a new job-producing engine for the U.S. economy.

This year we honor the legacy of President John F. Kennedy, who 50 years ago, set the United States on a path that resulted in a national effort to produce an unprecedented achievement. Now, we step forward along a similar path, engaged in a wide range of activities in human spaceflight, technology development, science, and aeronautics—a path characterized by engagement of an expanded commercial space sector and technology development to mature the capabilities required by increasingly challenging missions designed to make discoveries and reach new destinations.

NASA's Science Mission Directorate (SMD) continues to rewrite textbooks and make headlines around the world. Across disciplines and geographic regions worldwide, NASA aims to achieve a deep scientific understanding of Earth, other planets and solar system bodies, our star system in its entirety, and the universe beyond. The Agency is laying the foundation for the robotic and human expeditions of the future while meeting today's needs for scientific information to address national concerns about global change, space weather, and education.

- The Mars Science Laboratory will launch later this year and arrive at Mars in August 2012. It will be the largest rover ever to reach the Red Planet and will search for evidence of both past and present life.
- The Nuclear Spectroscopic Telescope Array (NuSTAR) mission will launch in early 2012 and become the first focusing hard X-ray telescope to orbit Earth.
- Research and Analysis programs will use data from an array of sources, including spacecraft, sounding rockets, balloons, and payloads on the ISS. We will continue to evaluate the vast amounts of data we receive from dozens of ongoing missions supported by this budget.
- A continued focus on Earth Science sees us continuing development of the Orbiting Carbon Observatory-2 (OCO–2) for launch in 2013 and other initiatives to collect data about our home planet across the spectrum.
- The budget reflects the scientific priorities for astrophysics as expressed in the recent Decadal Survey of the National Academy of Sciences. The budget supports small-, medium-, and large-scale activities recommended by the Decadal Survey.
- The Radiation Belt Storm Probe mission will launch next year, and development of other smaller missions and instruments to study the Sun will get underway here on the ground.

With the appointment of a new Chief Scientist NASA will pursue an integrated, strategic approach to its scientific work across Mission Directorates and programs.

As we continue our work to consolidate the Exploration Systems and Space Operations Mission Directorates (ESMD and SOMD), both groups will support our current human spaceflight programs and continue work on technologies to expand our future capabilities.

- We will fly out the Space Shuttle in 2011, including STS–135 if funds are available, and then proceed with the disposition of most Space Shuttle assets after the retirement of the fleet. The Shuttle program accomplished many outstanding things for this Nation, and in 2012 we look forward to moving our retired Orbiters to museums and science centers across the country to inspire the next generation of explorers.
- Completing assembly of the U.S. segment of the ISS will be the crowning achievement of the Space Shuttle's nearly 30-year history. The ISS will serve as a fully functional and permanently crewed research laboratory and technology testbed, providing a critical stepping stone for exploration and future international cooperation, as well as an invaluable National Laboratory for non-NASA and nongovernmental users. During FY 2011, NASA will award a cooperative agreement to an independent non-profit organization (NPO) with responsi-

bility to further develop national uses of the ISS. The NPO will oversee all ISS research involving organizations other than NASA, and transfer current NASA biological and physical research to the NPO in future years.

- In 2012, we will make progress in developing a new Space Launch System (SLS), a heavy-lift rocket that will be the first step on our eventual journeys to destinations beyond LEO.
- We will continue work on a Multi Purpose Crew Vehicle (MPCV) that will build on the human safety features, designs, and systems of the Orion Crew Exploration Vehicle. As with the SLS, acquisition strategy decisions will be finalized by this summer.
- NASA will continue to expand commercial access to space and work with our partners to achieve milestones in the Commercial Orbital Transportation Services (COTS) Program, the Commercial Resupply Services (CRS) effort, and an expanded Commercial Crew Development (CCDev) program. As we direct resources toward developing these capabilities, we not only create multiple means for accessing LEO, we also facilitate commercial uses of space, help lower costs, and spark an engine for long-term job growth. While the request is above the authorized level for 2012, NASA believes the amount is critical, combined with significant corporate investments, to ensure that we will have one or more companies that can transport American astronauts to the ISS. With retirement of the Space Shuttle in 2011, this is a top Agency priority.
- Most importantly, NASA recognizes that these programmatic changes will continue to personally affect thousands of NASA civil servants and contractors who have worked countless hours, often under difficult circumstances, to make our human spaceflight, science, and aeronautics programs and projects successful. I commend the investment that these dedicated Americans have made and will continue to make in our Nation's space and aeronautics programs. These are tremendously exciting and dynamic times for the U.S. space program. NASA will strive to utilize our workforce in a manner that will ensure that the Nation maintains NASA's greatest asset—the skilled civil servants and contractors—while working to increase the efficiency and cost-effectiveness in all of its operations.
- The 21st Century Space Launch Complex program will focus on upgrades to the Florida launch range, expanding capabilities to support SLS, MPCV, commercial cargo/launch services providers, and transforming KSC into a modern facility that benefits all range users. The program will re-plan its activities based on available FY 2011 funding to align with 2010 NASA Authorization's focus areas, including cross organizational coordination between 21stCSLC, Launch Services, and Commercial Crew activities.

NASA's Aeronautics Research Mission Directorate (ARMD) continues to improve the safety, efficiency and environmental friendliness of air travel.

- Our work continues to address the challenge of meeting the growing technology and capacity needs of the Next Generation air travel system, or "NextGen," in coordination with the FAA and other stakeholders in airspace efficiency.
- NASA's work on green aviation technologies that improve fuel efficiency and reduce noise continues apace.
- We also continue to work with industry to develop the concepts and technologies for the aircraft of tomorrow. The Agency's fundamental and integrated systems research and testing will continue to generate improvements and economic impacts felt by the general flying public as well as the aeronautics community.

The establishment last year of the Office of the Chief Technologist (OCT) enabled NASA to begin moving toward the technological breakthroughs needed to meet our Nation's space exploration goals, while building our Nation's global economic competitiveness through the creation of new products and services, new business and industries, and high-quality, sustainable jobs. By investing in high payoff, disruptive technology that industry cannot tackle today, NASA matures the technology required for our future missions in science and exploration while improving the capabilities and lowering the cost of other government agencies and commercial activities.

- In OCT's cross-cutting role, NASA recently developed draft space technology roadmaps, which define pathways to advance the Nation's capabilities in space and establish a foundation for the Agency's future investments in technology and innovation. NASA is working collaboratively with the National Research Council (NRC) to refine these roadmaps. The final product will establish a

mechanism for prioritizing NASA's technology investments, and will support the initial Space Technology Policy Congress requested in the NASA Authorization Act.

- As leader of the Space Technology Program, OCT will sponsor a portfolio of both competitive and strategically-guided technology investments, bringing the agency a wide range of mission-focused and transformative technologies that will enable revolutionary approaches to achieving NASA's current and future missions.
- In FY 2012, a significant portion of the Exploration Technology Development Program is moved from ESMD to Space Technology. These efforts focus on developing the long-range, exploration-specific technologies to enable NASA's deep space human exploration future. The integration of Exploration Technology activities with Space Technology creates one robust space technology budget line, and eliminates the potential for overlap had NASA's space technology investments been split among two accounts. ESMD will continue to set the prioritized requirements for these efforts and will serve as the primary customer of Space Technology's Exploration-specific activities.
- OCT continues to manage SBIR and STTR, and integrates technology transfer efforts ensure NASA technologies are infused into commercial applications, develops technology partnerships, and facilitates emerging commercial space activities.

Recognizing that our work must continuously inspire not only the public at large but also students at all levels, NASA's Education programs this year focus on widening the pipeline of students pursuing coursework in science, technology, engineering and mathematics (STEM). As President Obama has said, "Our future depends on reaffirming America's role as the world's engine of scientific discovery and technological innovation. And that leadership tomorrow depends on how we educate our students today, especially in math, science, technology, and engineering."

- The FY 2012 request for NASA's Office of Education capitalizes on the excitement of NASA's mission through innovative approaches that inspire educator and student interest and proficiency in STEM disciplines. NASA's education program in FY 2012 and beyond will focus and strengthen the Agency's tradition of investing in the Nation's education programs and supporting the country's educators who play a key role in inspiring, encouraging, and nurturing the young minds of today, who will manage and lead the Nation's laboratories and research centers of tomorrow.
- Among NASA's Education activities will be a continued Summer of Innovation, building on the successful model piloted with four states this past year.

All of these activities place NASA in the forefront of a bright future for America, where we challenge ourselves and create a global space enterprise with positive ramifications across the world. The FY 2012 budget request provides the resources for NASA to innovate and make discoveries on many fronts, and we look forward to implementing it. See Enclosure 2 for a more detail summary of each activity.

**Conclusion**

As we enter the second half-century of human spaceflight, the Nation can look back upon NASA's accomplishments with pride, but we can also look forward with anticipation to many more achievements to come. The NASA Authorization Act of 2010 (P.L. 111–267) has provided us with clear direction that enables the Agency to conduct important research on the ISS, develop new launch vehicle and crew transportation capabilities to go beyond the bounds of LEO, utilize a dazzling array of spacecraft to study the depths of the cosmos while taking the measure of our home planet, improve aviation systems and safety, develop new technologies that will have applications to both space exploration and life on Earth, and inspire the teachers and students of our country. In developing and executing the challenging missions that only NASA can do, we contribute new knowledge and technologies that enhance the Nation's ability to compete on the global stage and help to secure a more prosperous future.

These are tough fiscal times, calling for tough choices. The President's FY 2012 budget request makes those choices and helps NASA realize its potential and meet the challenges of the 21st Century. We look forward to working with the Committee on its implementation.

National Aeronautics and Space Administration President's FY 2012 Budget Request Detail—Full Cost View

| Budget Authority, $ in million | Actual FY 2010 | CR FY 2011 | Auth Act FY 2011 | FY 2012 | FY 2013 | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|---|---|---|---|---|
| Science | 4,497.6 | 4,469.0 | 5,005.6 | 5,016.8 | 5,016.8 | 5,016.8 | 5,016.8 | 5,016.8 |
| Earth Science | 1,439.3 | | 1,801.8 | 1,797.4 | 1,821.7 | 1,818.5 | 1,858.2 | 1,915.4 |
| Planetary Science | 1,364.4 | | 1,485.7 | 1,540.7 | 1,429.3 | 1,394.7 | 1,344.2 | 1,256.8 |
| Astrophysics | 647.3 | | 1,076.3 | 682.7 | 758.1 | 775.5 | 779.8 | 810.9 |
| James Webb Space Telescope | 438.7 | | 373.7 | 375.0 | 375.0 | 375.0 | 375.0 | |
| Hellophysics | 608.0 | | 641.9 | 622.3 | 632.7 | 653.0 | 659.7 | 658.7 |
| Aeronautics | 497.0 | 501.0 | 579.6 | 569.4 | 569.4 | 569.4 | 569.4 | 569.4 |
| Space Technology | 275.2 | 327.2 | 512.0 | 1,024.2 | 1,024.2 | 1,024.2 | 1,024.2 | 1,024.2 |
| Exploration | 3,625.8 | 3,594.3 | 3,706.0 | 3,948.7 | 3,948.7 | 3,948.7 | 3,948.7 | 3,948.7 |
| Human Exploration Capabilities | 3,287.5 | | 2,751.0 | 2,810.2 | 2,810.2 | 2,810.2 | 2,810.2 | 2,810.2 |
| Commercial Spaceflight | 39.1 | | 612.0 | 850.0 | 850.0 | 850.0 | 850.0 | 850.0 |
| Exploration Research and Development | 299.2 | | 343.0 | 288.5 | 288.5 | 288.5 | 288.5 | 288.5 |
| Space Operations | 6,141.8 | 6,146.8 | 5,508.5 | 4,346.9 | 4,346.9 | 4,346.9 | 4,346.9 | 4,346.9 |
| Space Shuttle | 3,101.4 | | 1,609.7 | 664.9 | 79.7 | 0.8 | 0.8 | 0.9 |
| International Space Station | 2,312.7 | | 2,779.8 | 2,841.5 | 2,960.4 | 3,005.4 | 3,098.0 | 3,174.8 |
| Space and Flight Support (SFS) | 727.7 | | 1,119.0 | 840.6 | 1,306.8 | 1,340.7 | 1,248.1 | 1,171.2 |
| Education | 180.1 | 182.5 | 145.8 | 138.4 | 138.4 | 138.4 | 138.4 | 138.4 |
| Cross-Agency Support | 3,017.6 | 3,018.8 | 3,111.4 | 3,192.0 | 3,192.0 | 3,192.0 | 3,192.0 | 3,192.0 |
| Center Management and Operations | 2,161.2 | | | 2,402.9 | 2,402.9 | 2,402.9 | 2,402.9 | 2,402.9 |
| Agency Management and Operations | 766.2 | | | 789.1 | 789.1 | 789.1 | 789.1 | 789.1 |
| Institutional Investments | 27.2 | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Congressionally Directed Items | 63.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Construction and Environmental Compliance and Restoration | 452.8 | 448.3 | 394.3 | 450.4 | 450.4 | 450.4 | 450.4 | 450.4 |
| Construction of Facilities | 389.4 | | | 397.9 | 384.0 | 359.5 | 362.9 | 360.0 |
| Environmental Compliance and Restoration | 63.4 | | | 52.5 | 66.4 | 90.9 | 87.5 | 90.4 |
| Inspector General | 36.4 | 36.4 | 37.0 | 37.5 | 37.5 | 37.5 | 37.5 | 37.5 |
| NASA FY 2011 | 18,724.3 | 18,724.3 | 19,000.0 | 18,724.3 | 18,724.3 | 18,724.3 | 18,724.3 | 18,724.3 |

PROGRAM SUMMARIES

## Science

The President's FY 2012 request for NASA includes $5,016.8 million for Science. NASA continues to expand humanity's understanding of our Earth, our Sun, the solar system, and the universe with 56 science missions in operation and 28 more in various stages of development. The Science budget funds these missions as well as the research of over 3,000 scientists, engineers, technologists, and their students across the Nation. NASA is guided in setting its priorities for strategic science missions by the recommendations of the NRC decadal surveys. The Agency selects competed missions and research proposals based on open competition and peer review. NASA's science efforts continue to advance a robust and scientifically productive program while making difficult choices commensurate with the Government-wide priority to constrain the Federal budget.

The challenges we face have been amplified by the failed launch of the Glory satellite on March 4. This loss is tragic and underscores the challenging nature of the

space business. Reliable and affordable access to space is vital to NASA's science program

The FY 2012 budget request includes $1,797.4 million for *Earth Science*. NASA's constellation of Earth observing satellites provides much of the global environmental observations used for climate research in the United States and abroad.

In early FY 2012, NASA plans to launch the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP), continuing selected climate data records and becoming an integral part of the Nation's operational meteorological satellite system for weather prediction. We also plan to select new Venture Class science instruments and small missions in FY 2012.

The Aquarius instrument on the Argentine Satélite de Aplicaciones Científicas (SAC)-D mission (launching later this year) will deliver the first global ocean salinity measurements to the science community in FY 2012. The Orbiting Carbon Observatory 2 (OCO–2), Landsat Data Continuity Mission (LDCM), and the Global Precipitation Measurement (GPM) missions will be in integration and testing in FY 2012. The first two NRC Decadal Survey missions, Soil Moisture Active/Passive (SMAP) and the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2), will both enter into development during FY 2012. This budget request also funds robust Research and Analysis, Applied Science, and Technology programs. In this climate of fiscal austerity there are some important capabilities that will not be developed in order to keep others on track in more constrained future years. Development of the second two Tier 1 Decadal Survey missions, the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI), and the Climate Absolute Radiance and Refractivity Observatory (CLARREO), has been deferred resulting in launch dates no earlier than 2020. NASA will continue pre-formulation work on the DESDynI and review international partner options. However, the FY 2012 request enables the Gravity Recovery And Climate Experiment Follow-on (GRACE–FO), the Pre-Aerosols-Clouds-Ecosystems (PACE), and the Tier 2 missions Surface Water and Ocean Topography (SWOT), and Active Sensing of $CO_2$ Emissions Over Nights, Days, and Seasons (ASCENDS) to go forward as planned.

The Science budget request includes $1,540.7 million for *Planetary Science* in FY 2012. NASA and its partners consider the period from October 2010 to August 2012 (the length of a Martian year) to be the "Year of the Solar System."

The Juno mission will launch in August 2011 and arrive at Jupiter in 2016. The Gravity Recovery And Interior Laboratory (GRAIL) mission, following launch in September 2011, will enter lunar orbit and help determine the structure of the lunar interior from crust to core; the mission will advance our understanding of the thermal evolution of the Moon by the end of its prime mission in FY 2012. A newly installed webcam is giving the public an opportunity to watch technicians assemble and test NASA's MSL "Curiosity," one of the most technologically advanced interplanetary missions ever designed. More than one million people have watched assembly and testing of Curiosity via a live webcam since it went on-line in October. Curiosity will launch in early FY 2012 and arrive at Mars in August 2012; it will be two times as large and three times as heavy as the Spirit and Opportunity rovers, and will focus on investigating whether conditions on Mars have been favorable for microbial life and for preserving clues in the rocks about possible past life. The MErcury Surface, Space ENvironment, GEochemistry and Ranging (MESSENGER) spacecraft will arrive at Mercury later this month and will complete its first year in Mercury orbit in March 2012. MESSENGER's instruments will map nearly the entire planet in color, image the surface in high resolution, and measure the composition of the surface, atmosphere and nature of the magnetic field and magnetosphere. During its nearly decade-long mission, the Dawn mission will study the asteroid Vesta and dwarf planet Ceres—celestial bodies believed to have accreted early in the history of the solar system. Dawn will enter into orbit around Vesta this summer and will depart in 2012 for its encounter with Ceres in 2015. NASA and the European Space Agency (ESA) have selected the five science instruments for the 2016 ExoMars Trace Gas Orbiter mission. The budget also supports robust Research and Analysis and Technology programs.

NASA recently received the new National Academy of Sciences Decadal Survey for Planetary Science, entitled Vision and Voyages for Planetary Science in the Decade 2013—2022. We are grateful to the Academy and to all the Survey participants for their hard work and thoughtful recommendations . NASA will use this survey to prioritize ongoing programs and future mission opportunities.

The FY 2012 budget request includes $682.7 million for *Astrophysics* (not including an additional $375 million for the James Webb Space Telescope [JWST] which is detailed below). This is a golden age of space-based Astrophysics, with 14 observatories in operation. Astrophysics research, technology investments, and missions aim to understand how the universe works, how galaxies, stars and planets origi-

nated and developed over cosmic time, and whether Earth-like planets and life exist elsewhere in the cosmos.

The FY 2012 budget request reflects the scientific priorities of the new National Academy of Science Decadal Survey entitled, "New Worlds, New Horizons in Astronomy and Astrophysics." The budget includes additional funding for the Explorer mission selection planned for 2012, sustains a vigorous flight rate of future astrophysics Explorer missions and missions of opportunity, and increases investments in recommended research and technology initiatives. Funding is also provided for pre-formulation investments in recommended large missions beyond JWST, while work on the Space Interferometry Mission (SIM) and Joint Dark Energy Mission (JDEM) has been brought to a close, consistent with the recommended Decadal Survey program. SOFIA will complete its open door flight testing and conduct the first competed science observations in FY 2012. The Nuclear Spectroscopic Telescope Array (NuSTAR) mission will launch in early 2012. The NASA Astrophysics budget also supports continuing operations of Hubble, Chandra, and several other astrophysics observatories in space. The budget increases funding for the core Astrophysics research program, including sounding rocket and balloon suborbital payloads, theory, and laboratory astrophysics.

The FY 2012 budget request includes $375 million for the *James Webb Space Telescope (JWST)*. JWST is now budgeted as a separate theme, reflecting changes implemented in FY 2011 to improve management oversight and control over this critical project, as recommended by the Independent Comprehensive Review Panel's (ICRP) report in November 2010. The project, previously managed within the Astrophysics Division, is now managed by a separate program office at NASA Headquarters. Management of this JWST organization at Headquarters now reports directly to the NASA Associate Administrator and the Associate Administrator for Science. The Goddard Space Flight Center has implemented analogous changes, with JWST project management now reporting directly to the Center Director. JWST was the top priority large mission recommended in the previous NRC Decadal Survey and is considered a foundational element of the science strategy in the new Decadal Survey for Astronomy and Astrophysics. During 2010, JWST completed its most significant mission milestone to date, the Mission Critical Design Review. Cost growth and schedule issues identified following this milestone led to the formation of the ICRP. The ICRP report concluded that the problems causing cost growth and schedule delays on the JWST project are associated with cost estimation and program management, not technical performance. The $375 million funding in 2012 gives the program a stable footing to continue progress while the agency develops a revised program plan that includes a realistic assessment of schedule and lifecycle cost. The revised schedule and lifecycle cost will be reflected in the 2013 Budget request.

The FY 2012 budget request includes $622.3 million for *Heliophysics*. NASA's heliophysics satellites provide not only a steady stream of scientific data for NASA's research program, but also supply a significant fraction of critical space weather data used by other Government agencies for support of commercial and national security activities in space. Those agencies use the data to protect operating satellites, communications, aviation and navigation systems, as well as electrical power transmission grids. The spacecraft also provides images of the Sun with ten times greater resolution than high-definition television in a broad range of ultraviolet wavelengths. On February 6, 2011, the two STEREO spacecraft reached 180 degrees separation; when combined with SDO, these spacecraft will enable constant imaging of the full solar sphere for the next eight years, as the solar cycle peaks and begins to decline again. These three spacecraft working together and in combination with NASA's other solar observatories will give us unprecedented insight into the Sun and its dangerous solar storms that could threaten both satellites and humans in space as well as electric power systems on Earth. NASA has begun development of a mission, called Solar Probe Plus, that will visit and study the Sun from within its corona—a distance only 8.5 solar radii above its surface.

The FY 2012 budget will enable completion of the Radiation Belt Storm Probes mission for launch in FY 2012 as well as the completion of development of the Interface Region Imaging Spectrograph (IRIS) Explorer mission. In FY 2012, the Magnetospheric Multiscale (MMS) mission will enter its assembly and integration phase, the Solar Orbiter Collaboration with ESA will undergo Mission Confirmation Review, and the Solar Probe Plus mission will enter into the preliminary design phase. NASA has increased funding for the next Explorer mission selection planned for 2012 to enable selection of up to two full missions, as well as instruments that may fly on non-Explorer spacecraft. The budget also supports robust Research and Analysis and Sounding Rocket operations programs. The National Academy of

Sciences has begun work on the next Decadal Survey for Heliophysics and we anticipate its release in the spring of 2012.

**Aeronautics Research**

The FY 2012 budget request for Aeronautics is $569.4 million. As an industry, aviation contributes $1.3 trillion to the Nation's economy and employs over one million people. Airlines in the U.S. transport over one million people daily, but during peak travel times the air traffic and airport systems in the U.S. are stretched to capacity. Environmental concerns, such as aircraft noise and emissions, limit increased operations and the expansion of airports and runways. In response to these challenges, the Nation is pursuing the realization of the Next Generation Air Transportation System (NextGen). NextGen will accommodate more aircraft operating within the same airspace, including aircraft with widely varying performance characteristics. The President recently challenged the Nation to increase its competitiveness in advanced technologies. NASA meets this challenge with aeronautics research to create the safer, more fuel-efficient, quieter, and environmentally responsible aircraft and air traffic management procedures needed to make NextGen a reality.

- *The Aviation Safety Program* conducts research to ensure that current and new aircraft and operational procedures maintain the high level of safety which the American public has come to count on, even as aviation systems become more complex. Last year, the Program published guidelines on automation, displays, and alerting technologies for future aircraft cockpit designs based on data collected from real flight crews during simulations of high-air-traffic-density operations. Further increases in air traffic will require even higher levels of automation without sacrificing safety. NASA is addressing this need by developing new methods to verify and validate complex aircraft and air traffic control systems and further developing human performance models to be applied in the design of automated systems. The Program is also developing data mining methods that will enable the discovery of safety issues through automated analysis of the vast amounts of data generated during flight operations. These methods will enable a new, proactive approach to aircraft maintenance and design to avoid the occurrence of safety issues, rather than a reactive approach after a safety-related incident occurs.
- Reductions in environmental impact will be achieved not only through new aircraft, engines, and fuels, but also through improved air traffic management procedures. *The Airspace Systems Program* is developing these procedures in order to provide the flexibility needed to add capacity to the system as air travel demands increase. Last year, we partnered with the Federal Aviation Administration (FAA), Boeing, Sensis, United Airlines, and Continental Airlines to complete joint simulations of new Efficient Descent Advisor (EDA) procedures, and in FY 2012, the Program will deliver documentation of the results to the FAA. EDA procedures are a key component of the FAA's 3D–Path Arrival Management program and NextGen and can save hundreds of pounds of fuel and carbon dioxide emissions per participating flight, while reducing noise over surrounding communities. In FY 2012, we will also accelerate field trials of new procedures enabled by Automatic Dependent Surveillance-Broadcast (ADS–B) technology. This effort will demonstrate near-term and mid-term ADS–B application benefits and provide airlines with data to support their strategic decisions related to the significant investments they need to make to equip their aircraft with ADS–B capability.
- *The Fundamental Aeronautics Program* seeks to continually improve technology that can be infused into today's state-of-the-art aircraft, while enabling game-changing new concepts, such as Hybrid Wing Body (HWB) airframes, tilt-rotor aircraft, low-boom supersonic aircraft, and sustained hypersonic flight. In FY 2012, the Program will accelerate research on a number of key enabling technologies identified through four conceptual design studies completed last year in collaboration with industry and academia. The Program will also expand the measurement of emissions generated when using non-petroleum alternative aircraft fuels. In FY 2012, we will develop instrumentation and operating procedures in preparation for a flight test campaign using the NASA DC–8 aircraft operating at relevant altitudes and cruise speeds. This will provide the first-ever data to improve our understanding of alternative fuel impact on contrail formation, an important factor in aviation climate impact.
- *The Integrated Systems Research Program* evaluates and selects the most promising "environmentally friendly" engine and airframe concepts emerging from the fundamental research programs for further development, integration, and

evaluation in relevant environments. Last year, we completed the last of 80 flights to explore the stability and control characteristics of the sub-scale X–48B HWB aircraft. In FY 2012, we will conduct the first-ever testing of an Hybrid Wing Body non-circular fuselage section fabricated using a new low-weight, damage-tolerant concept for composite aircraft structures. Beginning this year, the Program is also addressing the growing requirement to integrate unmanned aircraft systems (UAS) into the national airspace system. Current FAA regulations are built upon the condition of a pilot being on-board the aircraft. The Program will therefore generate data for FAA use in rule-making through development, testing, and evaluation of UAS technologies in operationally relevant scenarios. U.S. leadership in aerospace depends on ready access to technologically-advanced, efficient, and affordable aeronautics test capabilities. NASA's *Aeronautics Test Program* makes strategic investments to ensure the availability of these ground test facilities and flight test assets to researchers in Government, industry, and academia. In addition to this strategic management activity, the Program will continue with the development of new test instrumentation and test technologies. The Program is modifying a Gulfstream III business jet in order to flight test a new approach to reducing drag on an aircraft by adding carefully engineered surface roughness to the wings. This new flight-test capability will enable us to test this drag reduction concept for the first time at the altitudes and speeds at which commercial aircraft typically cruise.

NASA cannot do all of these good things alone. Our partnerships with industry, academia, and other Federal agencies are critical to our ability to expand the boundaries of aeronautical knowledge for the benefit of the Nation. These partnerships foster a collaborative research environment in which ideas and knowledge are exchanged across all communities and help ensure the future competitiveness of the Nation's aviation industry. They also directly connect students with NASA researchers and our industrial partners and help to inspire students to choose a career in the aerospace industry.

**Space Technology**

The FY 2012 budget request includes $1,024.2 million for Space Technology, a modest increase above the FY 2012 levels projected in the NASA Authorization Act of 2010, consistent with the priority the Administration is placing on research, technology and innovation efforts across the Federal government. In FY 2012, Space Technology includes funding for longstanding Small Business Innovation Research and Small Business Technology Transfer programs (SBIR and STTR), technology transfer, crosscutting space technology programs formulated in FY 2011, and exploration technology programs that are being transferred into this account. NASA technology development activities under Space Technology will transform the Nation's capabilities for exploring space. Through this effort, NASA advances crosscutting and exploration-specific technology, performs technology transfer and technology commercialization activities, develops technology partnerships with other Government agencies, and coordinates the Agency's overall technology investment portfolio. The Office of the Chief Technologist (OCT) manages Space Technology.

Space Technology is the central NASA contribution to the President's revitalized research, technology and innovation agenda for the Nation. NASA's Space Technology portfolio responds with investments that reach all corners of the Nation—wherever there are innovative ideas and technical challenges to be solved. Advanced technologies are required to enable NASA's future science, aeronautics, and exploration missions. As demonstrated over many years, these same advanced technologies find their way into products and services available every day to the public. NASA's space technology is an innovation engine that invests in the high payoff, high-risk ideas and technologies of tomorrow that industry cannot tackle today. This unique work attracts bright minds into educational and career paths in STEM disciplines, enhancing the Nation's technological leadership position in the world and leaving a lasting imprint on the economic, national security, and geopolitical landscape. Through these technological investments, NASA and our Nation will remain at the cutting-edge.

In FY 2010 and the first quarter of FY 2011, NASA focused on planning, formulating and implementing the Space Technology project elements. The Agency received 1,400 responses to six Space Technology Requests For Information (RFIs) released during FY 2010. These inputs were invaluable in finalizing future Space Technology solicitations and demonstrate a strong interest in, and need for, significant NASA investment in space research and technology. NASA released solicitations for the ongoing Flight Opportunities and SBIR/STTR programs. In December 2010 NASA released the inaugural Space Technology Graduate Fellowships call. Consistent with provisions of the NASA Authorization Act, the Agency plans to re-

lease three additional high-priority solicitations spanning Space Technology's strategic investment areas. NASA also recently developed a draft set of 14 space technology roadmaps, which define pathways to advance the Nation's capabilities in space and establish a mechanism for prioritization of NASA's technology investments. Consistent with the NASA Authorization Act of 2010, NASA's space technology roadmaps are being evaluated and improved through a community-engaged process managed by the NRC that will produce a range of pathways and recommended priorities that advance the Nation's space capabilities.

NASA's Partnership Development and Strategic Integration activities develop key space technology partnerships and guide NASA's space technology investment decisions. OCT provides a primary entry point to industry and Government agencies for technology transfer and commercialization, interagency coordination and joint activities, intellectual property management, and partnership opportunities. The Office is also responsible for development of an Agency technology portfolio and strategically coordinates Agency technology investments through Center and Mission Directorate advisory committees and through the space technology roadmaps to ensure that Space Technology investments serve NASA's missions as well as the interests of other Government agencies and the Nation's aerospace industry.

The Agency's space technology investments include the Small Business Innovation Research and the Small Business Technology Transfer programs (SBIR and STTR). Small businesses have generated 64 percent of net new jobs over the past 15 years. NASA invests at least 2.5 percent of its extramural research and development in the SBIR program. The STTR program makes awards to small businesses for contracts for cooperative research and development with non-profit research institutions, such as universities. For STTR, NASA's investment exceeds 0.3 percent of its extramural research and development. For FY 2012, higher maximum awards for SBIRs are allowed, with Phase I awards that can reach $150,000 and, for Phase 2, up to $1 million. Also in FY 2012, NASA is aligning the SBIR and STTR topics with space technology roadmaps and the National Aeronautics Research and Development Plan, while coordinating with Centers and maintaining a Mission Directorate steering council to continue to improve our rate of mission infusion.

Crosscutting Space Technology Development (CSTD) activities invest in broadly applicable technologies though early-stage conceptual studies, ground-based and laboratory testing, relevant-environment flight demonstrations, and technology testbeds, including the ISS. The NASA Mission Directorates, other Government agencies, and industry are the ultimate customers for Crosscutting Space Technology Development products. Within this element, there are three investment areas: Early Stage Innovation, Game Changing Technology and Crosscutting Capability Demonstrations. Early Stage Innovation funds space technology research grants and fellowships to accelerate space technology development through innovative projects with high risk/high payoff. It also funds the NASA Innovative Advanced Concepts (NIAC) effort, which studies the viability and feasibility of space architecture, system, or mission concepts. It includes the Center Innovation Fund to stimulate and encourage creativity and innovation within the NASA Centers, and provides the prizes for the Centennial Challenges competitions that seek innovative solutions to technical problems in aerospace technology. Through ground-based and laboratory testing, Game Changing Technology proves the fundamental physical principles of those technologies that can provide transformative capabilities for scientific discovery, and human and robotic exploration. Specifically for small satellites, the *Franklin* subsystem technology development activity matures subsystem technology in laboratory environments. Crosscutting Capability Demonstrations proves the most promising technological solutions in the relevant environment of space. Technology Demonstration Missions prove larger-scale system technologies in the space environment, whereas the *Edison* small satellite missions demonstrate the utility of these innovative space platforms for NASA's future missions. Flight Opportunities utilizes the capabilities of the commercial reusable suborbital space transportation and parabolic flight services industries to test technologies. Seventy percent of the CSTD funds will be awarded competitively, with solicitations open to the broad aerospace community to ensure engagement with the best sources of new and innovative technology. Industry, academia and the NASA Centers will participate in the development of CSTD products. In FY 2012, CSTD will engage hundreds of graduate students and researchers though grants and fellowships, initiate dozens of ground and flight technology demonstrations, initiate tens of technology studies, and formulate its first demonstration missions.

In FY 2012, a significant portion of the FY 2010 Exploration Technology Development Program, as well as new exploration technology activities in planning for FY 2011, will move from ESMD to Space Technology. For traceability, the transferred activities have been consolidated in a specific budgetary element within Space Tech-

nology: Exploration Technology Development (ETD). NASA plans to capitalize on technical synergies in the project elements from Crosscutting Space Technology Development and Exploration Technology Development by managing these programs in an integrated manner. Technologies within ETD enable NASA to conduct future human missions beyond LEO with new capabilities that have greater affordability. Technologies for future human exploration missions are matured through ground-based and laboratory testing, relevant environment flight demonstrations, and technology testbeds, including the ISS. Technologies matured through demonstration flights may then be designed into future NASA human exploration missions with acceptable levels of risk. Exploration is the ultimate customer for Exploration Technology Development products. In addition to ongoing-guided Exploration-specific technology development activities, in FY 2012, NASA will use 30 percent of the funds within this account to fund competitive awards, drawing proposals from industry, academia, and the NASA Centers for innovative Exploration-specific technologies and demonstration missions.

**Exploration**

The FY 2012 budget request for Exploration is $3,948.7 million. In FY 2012 and beyond, NASA's Exploration programs will continue to support the U.S. economy by enabling safe, reliable and cost effective U.S.-provided commercial access to LEO for crew and cargo as soon as possible. Included in this budget request is funding for three new, robust categories or "themes" that will expand the capabilities of future space explorers far beyond those we have today: Human Exploration Capabilities, Commercial Spaceflight, and Exploration Research and Development. These systems and capabilities include launch and crew vehicles for missions beyond LEO—the Moon, asteroids, and eventually Mars, affordable commercial crew access to the ISS, and technologies and countermeasures to keep astronauts healthy and productive during deep space missions, and to reduce the launch mass and cost of deep space missions.

The FY 2012 budget request includes $2,810.2 million for *Human Exploration Capability (HEC)*. HEC is the successor to the Constellation Systems theme; programs and projects under HEC will develop the launch vehicles and spacecraft that will provide the initial capability for crewed exploration missions beyond LEO. In particular, HEC's Space Launch System (SLS) Program will develop the heavy-lift vehicle that will launch the crew vehicle, other modules, and cargo for these missions. The Multi-Purpose Crew Vehicle (MPCV) Program will develop the vehicle that will carry the crew to orbit, provide emergency abort capability, sustain the crew while in space, and provide safe re-entry from deep-space return velocities. NASA is currently developing plans for implementing the SLS and MPCV programs, including efforts to transition the design and developmental activities of the Constellation Program. A major element of the transition involves shifting design and developmental efforts away from a closely coupled system (Ares I and Orion) to a more general launch vehicle (the SLS) and crew vehicle (the MPCV).

Consistent with direction in the NASA Authorization Act of 2010, the Agency has developed a Reference Vehicle Design for the SLS that is derived from Ares and Space Shuttle hardware. The current concept vehicles would utilize a liquid oxygen/liquid hydrogen core with five RS–25 Space Shuttle Main Engine (SSME)-derived engines, five-segment solid rocket boosters, and a J-2X-based Upper Stage for the SLS. This would allow for use of existing Shuttle and Ares hardware assets in the near term, with the opportunity for upgrades and/or competition downstream for eventual upgrades in designs needed for affordable production. For the MPCV, NASA has chosen the beyond-LEO design of the Orion Crew Exploration Vehicle as the Reference Vehicle Design for the MPCV. The Orion development effort has already benefited from significant investments and progress to date, and the Orion requirements closely match MPCV requirements as defined in the Authorization Act, which include utilizing the MPCV for beyond-LEO crew transportation and as backup for ISS crew transportation.

NASA will evaluate the Reference Vehicle Designs this spring and incorporate results of industry studies that the Agency solicited earlier this Fiscal Year. In particular, one of the greatest challenges for NASA is to reduce the development and operating costs for human spaceflight missions to sustain a long-term U.S. human spaceflight program. We must plan and implement an exploration enterprise with costs that are credible, sustainable, and affordable for the long term under constrained budget environments. As such, our development efforts will be dependent on sufficiently stable funding over the long term, coupled with a successful effort on the part of NASA and the eventual industry team to reduce costs and to establish stable, tightly-managed requirements.

NASA plans to approach affordability comprehensively in pursuit of exploration beyond LEO to increase the probability that key elements are developed and missions can occur within a realistic budget profile. For all development activities, we will emphasize innovative acquisition and program management approaches, including risk management, to reduce recurring and operations costs. In doing so, plans for bringing the MPCV and SLS vehicles online with lower costs will be as credible and realistic as possible, and significant efforts will be made to ensure cost risks will be well understood. Overall, NASA's designs and acquisition strategies for the MPCV and SLS Programs will not be solidified until all of the pertinent knowledge on cost and safety is obtained to ensure an affordable and executable solution. NASA expects to finalize acquisition strategies this summer, and will obtain independent, external assessments of cost and schedule for SLS and MPCV design options during the spring or summer timeframe. We will share this information with the Congress—including Members of this Committee—as soon as we are able to do so.

The FY 2012 budget request includes $850.0 million for the *Commercial Spaceflight* theme in Exploration. This effort will provide incentives for commercial providers to develop and operate safe, reliable, and affordable commercial systems to transport crew and cargo to and from the ISS and LEO. This approach will provide assured access to the ISS, strengthen America's space industry, and provide a catalyst for future business ventures to capitalize on affordable access to space. A vibrant commercial space industry will add well-paying, high-tech jobs to the U.S. economy, and will reduce America's reliance on foreign systems.

In 2010, NASA further expanded its successful Commercial Crew Development (CCDev) Program by initiating CCDev2 in October 2010. In doing so, we solicited proposals to further advance commercial crew transportation system concepts and mature the design and development of system elements, such as launch vehicles and spacecraft. Depending on available funding in FY 2011, we expect to select a series of CCDev2 proposals for award early this year. Once finalized, the resulting CCDev2 agreements should result in significant maturation of commercial crew transportation system capabilities, with consideration given to NASA's draft human certification requirements and standards or the industry equivalent to those requirements and standards.

Beginning in FY 2012, NASA proposes to take the accomplishments and lessons learned from the successes of the first two rounds of CCDev and incorporate them into a new initiative called CCDev3. This initiative will facilitate the development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable and cost effective access to and from LEO and the ISS. Once the commercial crew transportation capability is matured and available to customers, NASA plans to purchase transportation services to meet its ISS crew rotation and emergency return obligations.

For CCDev3, NASA plans to award competitive, pre-negotiated, milestone-based agreements that support the development, testing, and demonstration of multiple commercial crew systems. The acquisition strategy for CCDev3 is still in development, but it will feature pay-for-performance milestones, a fixed Government investment, the use of negotiated service goals instead of detailed design requirements, and a requirement for private capital investment.

In calendar year 2011 work on NASA's Commercial Orbital Transportation Services (COTS) Program will continue under the Commercial Spaceflight theme, using previous-year funding. Both of NASA's funded COTS partners continue to make progress in developing their cargo transportation systems, based in part on NASA's financial and technical assistance. In particular, on December 8, 2010, Space Exploration Technologies (SpaceX) successfully launched its Falcon 9 vehicle, and demonstrated separation of the Dragon spacecraft and completion of two full orbits, orbital maneuvering and control, reentry, parachute decent and spacecraft recovery after splashdown in the Pacific Ocean. For its part in COTS, NASA's second funded partner, Orbital Sciences Corporation (OSC), recently began integration and testing of its Cygnus Service Module and Taurus II launch vehicle. Both companies are expected to complete their remaining COTS demonstration flights in late 2011 or early 2012.

The FY 2012 budget request for ESMD includes $288.5 million for *Exploration Research and Development (ERD).* The Exploration Research and Development (ERD) theme will expand fundamental knowledge that is key to human space exploration, and will develop advanced exploration systems that will enable humans to explore space in a more sustainable and affordable way. ERD will be comprised of the Human Research Program (HRP) and the Advanced Exploration Systems (AES) Program, which will provide the knowledge and advanced human spaceflight capabilities required to implement the U.S. Space Exploration Policy

In FY 2012, HRP and its associated projects will continue to develop technologies, countermeasures, diagnostics, and design tools to keep crews safe and productive on long-duration space missions. As astronauts journey beyond LEO, they will be exposed to microgravity, radiation, and isolation for long periods of time. Keeping crews healthy and productive during long missions will require new technologies and capabilities. Therefore, continued research is required to study how the space environment, close quarters, heavy workloads, and prolonged time away from home contribute to stress, and then develop technologies that can prevent or mitigate these effects. More specifically, in FY 2012, HRP will support approximately 15–20 biomedical flight experiments on the ISS and deliver the next-generation space biomedical ultrasound device to enhance the Station's human research facility capability. Other activities will include development of a training program for ultrasound diagnosis of fractures and the evaluation of blood analysis technology for astronaut health monitoring. Additionally, HRP projects will deliver an enhanced design tool for vehicle radiation shielding assessments and release the second version of an acute radiation risk model. In the area of behavioral health and performance, researchers will complete a sleep-wake actigraphy report on the ISS crew. In order to support its research requirements, HRP will release two NASA Research Announcements addressing space radiation health risks and human physiological changes associated with spaceflight.

AES will continue projects from the Exploration Technology Development program that are close to application and closely tied to human safety in space. In FY 2012, AES will assume responsibility for developing and demonstrating innovative prototype systems to provide basic needs such as oxygen, water, food, and shelter that can operate dependably for at least a year. AES will demonstrate these systems in ground testbeds, Earth-based field and underwater tests, and ISS flight experiments. In FY 2012, AES will use a ground testbed to demonstrate the reliability of life support system components, and a portable life support system for an advanced space suit will be tested in a vacuum chamber. Ground-based analog field tests and underwater tests will validate a prototype Deep Space Habitat, where the crew will live during transit on long missions, and a Space Exploration Vehicle that will allow the crew to closely approach an asteroid, explore its surface, and conduct surface exploration outside the vehicle. AES plans to use innovative approaches for the rapid development of system concepts, such as small, focused teams of NASA engineers and technologists working with industry partners to gain hands-on experience. AES will pilot these processes to improve the affordability of future exploration programs.

**Space Operations**

The FY 2012 budget request includes $4,346.9 million for Space Operations, funding the Space Shuttle Program retirement, the International Space Station Program, the Space and Flight Support Program.

The FY 2012 budget request for the *Space Shuttle Program* is $664.9 million. In 2011, the Shuttle is slated to fly out its remaining missions. On March 9 Discovery completed mission STS–133, carrying supplies to ISS, as well as the permanent a Multi-purpose Module (PMM), a Multi-Purpose Logistics Module (MPLM) transformed to remain on orbit, expanding the Station's storage volume. In April 2011, Endeavour, STS–134, will carry the Alpha Magnetic Spectrometer (AMS) and attach it to the Station's truss structure. The final Shuttle mission, STS–135, is targeted for late June of this year, if funding is available. During the mission, Atlantis will deliver critical supplies to the ISS and recover and return to Earth an ammonia coolant pump module that failed on the Station last year.

Following the completion of the remaining missions in 2011, the Space Shuttle Program will focus on transition, retirement, and disposition of program assets and workforce. Approximately 1.2 million line items of personal property (*e.g.,* equipment) are associated with the Space Shuttle Program, with about 500,000 of these line items associated with the Space Shuttle propulsion system elements (the Reusable Solid Rocket Motor, the Solid Rocket Booster, the External Tank, and Space Shuttle Main Engines). As part of this effort, NASA will assess Space Shuttle property (including main propulsion system elements) applicability to the Space Launch System.

On April 12, 2011, we will celebrate the 50th anniversary of human spaceflight, and the 30th anniversary of the first flight of Space Shuttle Columbia on STS–1. NASA recognizes the role the Space Shuttle vehicles and personnel have played in the history of space activity, and looks forward to transitioning key workforce, technology, facilities, and operational experience to a new generation of human spaceflight exploration activities.

The FY 2012 budget request includes funding for Space Program Operations Contract (SPOC) Pension Liability. The United Space Alliance (USA) notified NASA of its desire to terminate all defined pension benefit plans as of December 31, 2010. USA has consistently incorporated and billed the maximum allowable costs into their indirect rates, but the recent deterioration of the equities and credit markets has caused their plan to be underfunded by an estimated $500-$600 million. The Space Program Operations Contract, which accounts for almost all of USA's business base, is a cost-type contract covered by the Cost Accounting Standards (CAS). These standards stipulate that any costs of terminating plans are a contractual obligation of the Government (if deemed allowable, allocable, and reasonable). NASA and USA entered into an agreement under which USA froze their pension plans as of December 31, 2010 and deferred any decision about terminating their plan until after December 31, 2011, allowing NASA to address this issue, if it arises, with FY 2012 funds, if appropriated. USA and NASA have instituted a working group to discuss pension termination options and have met with the Pension Benefit Guaranty Corporation to discuss potential options. If funding remains after the pension plan termination, it will be used to defray Space Shuttle closeout costs that would otherwise require FY 2013 funding. If there is a shortfall, it will reduce available Space Shuttle funds for closeout and some activity could move later than planned. We will keep Congress informed as this issue evolves.

The FY 2012 budget request for the *International Space Station (ISS) Program* is $2,841.5 million, of which $1,656 million is for operations, research, and utilization, and $1,186 million for crew and cargo transportation. The ISS has transitioned from the construction era to that of operations and research, with a 6-person permanent crew, 3 major science labs, an operational lifetime through at least 2020, and a growing complement of cargo vehicles, including the European Automated Transfer Vehicle (ATV) and the Japanese H–II Transfer Vehicle (HTV), the second flights of which are taking place even as we speak. The FY 2012 budget request reflects the importance of this unparalleled research asset to America's human spaceflight program.

In addition to conducting research in support of future human missions into deep space, astronauts aboard the ISS will carry out experiments anticipated to have terrestrial applications in areas such as biotechnology, bioengineering, medicine, and therapeutic treatment as part of the National Laboratory function of the Station. In support of this effort, NASA has recently released a Cooperative Agreement Notice (CAN) for a independent Non-Profit Organization to manage the multidisciplinary research carried out by NASA's National Laboratory partners. This organization will 1) act as a single entry point for non-NASA users to interface efficiently with the ISS; 2) assist researchers in developing experiments, meeting safety and integration rules, and acting as an ombudsman on behalf of researchers; 3) perform outreach to researchers and disseminate the results of ISS research activities; and 4) provide easily accessed communication materials with details about laboratory facilities, available research hardware, resource constraints, and more. The FY 2012 budget request for ISS reflects increased funding for the transportation required to support this research.

The ISS transportation budget also supports NASA's continued use of the Russian Soyuz spacecraft for crew transportation and rescue services, pending the availability of a domestic crew transportation system, as well as U.S. commercial cargo transportation. The ISS transportation budget supports NASA's Cargo Resupply Services suppliers as they continue to make progress towards fielding their cargo resupply vehicles, which will be critical to the maintenance of ISS after the retirement of the Space Shuttle. We anticipate that the first commercial resupply flight will take place by the end of this year, and that both providers will have their systems operational in 2012.

The FY 2012 budget request for *Space and Flight Support* (SFS) is $840.6 million. The budget request provides for critical infrastructure indispensable to the Nation's access and use of space, including Space Communications and Navigation (SCaN), Launch Services Program (LSP), Rocket Propulsion Testing (RPT), and Human Space Flight Operations (HSFO). The SFS budget also includes investment in the 21st Century Space Launch Complex, intended to meet the infrastructure requirements of the SLS, MPCV, and commercial cargo/launch services providers. It will increase operational efficiency and reduce launch costs by modernizing the Florida launch capabilities for a variety of NASA missions, which will also benefit non-NASA users

In FY 2012, the SCaN Program will continue to improve the robustness of the Deep Space Network (DSN) through its efforts to replace the aging 70m antenna capability with 34m antennae, launch Tracking and Data Relay Satellite (TDRS) K and continue the development of TDRS L. In the area of technology, we will conduct

on-orbit tests using the Communication Navigation and Networking Reconfigurable Testbed (CoNNeCT), integrate the optical communications system on the Lunar Atmosphere and Dust Environment Explorer (LADEE) spacecraft, and begin operational space mission use of Disruption Tolerant Networking communications. The SCaN operational networks will continue to provide communications and tracking services to over 75 spacecraft and launch vehicles during FY 2012. The LSP has several planned NASA launches in FY 2012 including the NPOESS Preparatory Project (NPP), MSL, Nuclear Spectroscopic Telescope Array (NuSTAR), TDRS–K, and RBSP, and will continue to provide support for the development and certification of emerging launch services. The RPT Program will continue to provide test facility management, and provide maintenance, sustaining engineering, operations, and facility modernization projects necessary to keep the test-related facilities in the appropriate state of operational readiness. HSFO includes Crew Health and Safety (CHS) and Space Flight Crew Operations (SFCO). SFCO will continue to provide trained crew for ISS long-duration crew rotation missions. CHS will identify and deliver necessary core medical capabilities for astronauts. In addition, CHS will gather astronaut medical data critical for determining medical risk as a result of spaceflight and how best to mitigate that risk. NASA has enlisted the National Research Council to conduct an independent study of the activities funded within NASA's HSFO program, focusing on the role, size, and training requirements of the human spaceflight office after Space Shuttle retirement and Space Station assembly completion.

The FY 2012 budget request also establishes a new line item called Mission Operations Sustainment, which will address future Space Operations functions essential to NASA's human spaceflight mission, including funding to purchase U.S. commercial crew transportation services to and from ISS once they are developed, and key ground and space infrastructure improvements required by the Space Network (SN) in order to accommodate anticipated demand in the outyears; the Mission Operations Sustainment budget would be utilized to fund this performance gap. Although the exact amount of funding required for these needs is unknown, it is clear that NASA's human spaceflight mission cannot be sustained without resources provided by Missions Operations Sustainment beyond FY12. The Agency will perform the requisite technical and program analysis and planning, and the results will be reflected in the FY 2013 budget request.

**Education**

The FY 2012 budget request for Education is $138.4 million. This budget request furthers NASA's commitment to inspiring the next generation of explorers in the science, technology, engineering, and mathematics, or STEM, disciplines. In FY 2012, NASA will continue to strongly support the Administration's STEM priorities and to capitalize on the excitement of NASA's mission to stimulate innovative solutions, approaches, and tools that inspire student and educator interest and proficiency in STEM disciplines. The Agency's education strategy will increase its impact on STEM education by further focusing K–12 efforts on middle-school pre-and in-service educator professional development. It includes an increased emphasis on providing experiential opportunities for students, internships, and scholarships for high school and undergraduate students. NASA higher education efforts will increasingly target community colleges, which generally serve a high proportion of minority students, preparing them for study at a four-year institution. NASA will use its unique missions, discoveries, and assets (*e.g.,* people, facilities, education infrastructures) to inspire student achievement and educator teaching ability in STEM fields.

In FY 2012, NASA will support the Administration's STEM education teaching and learning improvement efforts, including the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (America COMPETES) Reauthorization Act of 2010, Race to the Top and Educate to Innovate, while continuing efforts to incorporate NASA missions and content into the STEM education initiatives of other Federal agencies. This may include providing competitions and challenges, supporting clearinghouses of Federal STEM education resources, providing high quality professional development, and other engagements.

NASA will continue the Summer of Innovation (SoI) Pilot through partnerships with organizations that currently work with girls, minorities, and low-income students in grades 4–9 in summer and extended learning settings. The SoI project will deepen and broaden the efforts of communities and schools to successfully engage these students by providing high-quality, inquiry-based content, customized support, and access to NASA people, facilities and technology.

NASA will continue to partner with universities, professional education associations, industry, and other Federal agencies to provide K–12 teachers and university

faculty with experiences that capitalize on the excitement of NASA discoveries to spark student interest and involvement in STEM disciplines. Examples of experiences include research and hands-on engineering in our unique facilities and on a variety of real-world platforms that include high-altitude balloons, sounding rockets, aircraft, and satellites. NASA will also partner with science centers, museums, planetariums, and community-based education providers to allow informal educators to engage students in NASA's real-time, cutting-edge science and engineering discoveries and challenges. The FY 2012 budget request places increased emphasis on cyber-learning opportunities and the use of the ISS National Laboratory to engage students (at all levels) in launch activities, research and engineering grants, and courses based upon NASA science and engineering.

In FY 2012, the Agency aims to increase the availability of opportunities to a diverse audience of educators and students, including women, minorities, and persons with disabilities. An example is the Innovations in Global Climate Change Education project that will be implemented within the Minority University Research and Education Program (MUREP). The project provides opportunities for students and teachers to conduct research using NASA data sets to inspire achievement and improve teaching and learning in the area of global climate change.

**Cross-Agency Support**

The FY 2012 budget request includes $3,192.0 million for Cross Agency Support, which provides critical mission support activities that are necessary to ensure the efficient and effective operation and administration of the Agency. These important functions align and sustain institutional and program capabilities to support NASA missions by leveraging resources to meet mission needs, establishing Agency-wide capabilities, and providing institutional checks and balances. Within this budget request, NASA has taken steps to reduce its administrative expenses, including a partial hiring freeze and reduced travel.

NASA's FY 2012 budget request includes $2,402.9 million for *Center Management and Operations,* which funds the critical ongoing management, operations, and maintenance of nine NASA Centers and major component facilities. NASA Centers provide high-quality support and the technical engineering and scientific talent for the execution of programs and projects. Center Management and Operations provides the basic support required to meet internal and external legal and administration requirements; effectively manage human capital, information technology, and facility assets; responsibly execute financial management and all NASA acquisitions; ensure independent engineering and scientific technical oversight of NASA's programs and projects in support of mission success and safety considerations; and, provide a safe, secure, and sustainable workplace that meets local, state, and Federal requirements. Cross Agency Support also funds salary and benefits for civil service employees at NASA Centers who are assigned to work on Center Management and Operations projects. In addition, the account contains Center-wide civil service personnel costs, such as institutionally-funded training.

NASA's FY 2012 budget request includes $789.1 million for *Agency Management and Operations*, which funds the critical management and oversight of Agency missions, programs and functions, and performance of NASA-wide activities, including five programs: Agency Management, Safety and Mission Success, Agency Information Technology Services, Strategic Capabilities Assets Program, and Agency Management and Operations Civil Service Labor and Expenses. Agency Management supports executive-based, Agency-level functional and administrative management requirements, including, but not limited to: Health and Medical, Environmental, Logistics, General Counsel, Equal Opportunity and Diversity, Internal Controls, Procurement, Human Resources, and Security and Program Protection. Agency Management provides for the operational costs of Headquarters as an installation; institutional and management requirements for multiple Agency functions; assessment and evaluation of NASA program and mission performance; strategic planning; and, independent technical assessments of Agency programs.

Safety and Mission Success activities are required to continue improving the workforce, and strengthening our acquisition processes, including maintaining robust checks and balances, in order to improve the safety and likelihood of mission success for NASA's Programs throughout their lifecycles. The engineering, safety and mission assurance, health and medical independent oversight, and technical authority components are essential to NASA's success. They were established or modified in direct response to several major Government accident and mission failure investigation findings in order to reduce the likelihood of loss of life and/or mission in our human and robotic Programs. The budget request also supports operation of three activities that each provides a unique focus in support of the independent oversight and technical authority implementation: the Software Independent

Verification and Validation (IV&V) program; the NASA Engineering and Safety Center (NESC); and the NASA Safety Center located at the Glenn Research Center.

Agency Information Technology Services (AITS) encompasses Agency-level cross-cutting services and initiatives in Information Technology (IT) innovation, business and management applications, and infrastructure necessary to enable the NASA Mission. AITS includes management of NASA's scientific and technical information; identity, credential and access management services; overarching information security services; enterprise-level business systems; and, other Agency operational services, such as e-mail, directory services, and enterprise licenses. NASA's Security Operations Center (SOC) will continue to mature capabilities to improve security incident prevention, detection, response, and management. NASA will continue implementation of major Agency-wide procurements to achieve: (1) consolidation of IT networks leading to improved network monitoring, management and reliability; (2) consolidation of desktop/laptop computer services and mobile devices to achieve improved security and enable NASA Centers and programs to realize improved efficiencies; (3) consolidation of Agency public website/application management to improve the Agency security posture and to facilitate access to NASA data and information by the public; (4) minor enhancement and maintenance of integrated Agency business systems to provide more efficient and effective Agency operations; and, (5) reduction in overall Agency data centers and related infrastructure currently funded outside the AITS budget.

The Strategic Capabilities Assets Program (SCAP) funds key Agency test capabilities and assets, such as an array of flight simulators, thermal vacuum chambers, and arc jets, to ensure mission success. SCAP ensures that assets and capabilities deemed vital to NASA's current and future success are sustained in order to serve Agency and national needs. All assets and capabilities identified for sustainment either have validated mission requirements or have been identified as potentially required for future missions, either internally to NASA or by other Federal entities.

The Agency Management and Operations Civil Service Labor and Expenses funds salary and benefits for civil service employees at NASA Headquarters, as well as other Headquarters personnel costs, such as mandated training. It also contains labor funding for Agency-wide personnel costs, such as Agency training, and workforce located at multiple NASA Centers that provide the critical skills and capabilities required to execute mission support programs Agency-wide.

**Construction and Environmental Compliance and Restoration**

The FY 2012 budget request includes $450.4 million for Construction and Environmental Compliance and Restoration. NASA Construction and Environmental Compliance and Restoration provides for the design and execution of all facilities construction projects, including discrete and minor revitalization projects, demolition of closed facilities, and environmental compliance and restoration. The FY 2012 budget request includes $397.9 million for the *Construction of Facilities* (CoF) Program, which funds capital repairs and improvements to ensure that facilities critical to achieving NASA's space and aeronautics programs are safe, secure, sustainable, and operate efficiently. The Agency continues to place emphasis on achieving a sustainable and energy-efficient infrastructure by replacing old, inefficient, deteriorated buildings and horizontal infrastructure with new, efficient, and high performance buildings and infrastructure that will meet NASA's mission needs while reducing the Agency's overall footprint and future operating costs. The CoF program prioritizes this budget based on risk of impact to NASA and Center missions, safety issues and accessibility. The FY 2012 budget request includes $52.5 million for the *Environmental Compliance and Restoration* (ECR) Program, which supports the ongoing clean up of sites where NASA operations have contributed to environmental problems. The ECR Program prioritizes these efforts to ensure that human health and the environment are protected. This program also supports strategic investments in sustainable environmental methods and practices aimed at reducing NASA's environmental footprint and lowering the risk of future cleanups.

Senator NELSON. I want to start with you, Dr. Whitlow. I want you to tell us if a budget or continuing resolution were to be passed with the $298 million cut that would come off of a cross-agency support account, which is what passed the House of Representatives, how many jobs would that be that would be lost?

**STATEMENT OF DR. WOODROW WHITLOW, JR., ASSOCIATE ADMINISTRATOR, MISSION SUPPORT DIRECTORATE, NASA**

Dr. WHITLOW. With a cut of that magnitude, coming this time of year, which is halfway through the Fiscal Year, we estimate that it would require us to reduce about 4,500 contractor jobs across the agency. And that's about half of our onsite contractor work-year capability.

Senator NELSON. And do you recall, out of those 4,500, how many there would be cut from the Johnson Space Center?

Dr. WHITLOW. It's over 800; it's approximately 850.

Senator NELSON. And how many from the Kennedy Space Center?

Dr. WHITLOW. Somewhere—a little smaller than that, but I could take that for the record and get you an exact number.

[The information requested follows:]

The FY 2011 Full-Year Continuing Appropriations Act (P.L. 112–10), which was enacted on April 15, 2011, funds NASA Cross Agency Support (CAS) at the FY 2011 President's Request level. If the provision included in H.R. 1—directing a $298M reduction to NASA's Cross-Agency budget—had been enacted, the reductions would have occurred so late in the operating year that they would have resulted in thousands of layoffs to on-site contractors, with 50 percent of NASA's contractor workforce at risk. That level would equate to over 4,500 layoffs across all of NASA's Centers. The number of impacted jobs at KSC would have been approximately 730. As the reduction was not included in enacted legislation, the Agency did not proceed to make specific determinations for implementing such direction and no NASA Centers were identified for such an action.

Senator NELSON. Somewhere close, you said——

Dr. WHITLOW. Yes.

Senator NELSON.—to the 800 that would be lost——

Dr. WHITLOW. Correct.

Senator NELSON.—in the Johnson Space Center.

Dr. WHITLOW. Correct.

Senator NELSON. And explain that—since there are only 6 months left in the fiscal year, what would be the impact of implementing that cross-agency support cuts so late in the fiscal year?

Dr. WHITLOW. Well, the cross-agency support budget provides for the maintenance operation and management of our field centers and the associated installations across the agency. We have been spending at a rate that assumed no reductions to the cross-agency support budget this fiscal year. So, we now would have to take that full cut in half of the year, a cut of that magnitude would be equivalent to shutting, say, two of our smallest centers, and we would not be able to provide the capabilities to operate our facilities across the agency.

Senator NELSON. And what are the two centers that would shut down?

Dr. WHITLOW. Well, it's the equivalent to, say, two small centers. I have not considered any two specific centers, but just two smaller centers. Yes.

Senator NELSON. But, it could be something like Dryden? Could be something like Ames?

Dr. WHITLOW. It would be——

Senator NELSON. Could be something like Stennis?

Dr. WHITLOW. Yes, two of the smaller centers. But, we have not identified any two centers.

Senator NELSON. OK.

Mr. Cooke and Mr. Gerstenmaier, you heard what Senator Hutchison said. And there have been too many headlines recently that said that NASA can't, and won't, build a heavy-lift launcher. Now, that, of course, is not what the authorization law says. What is it that you understand the NASA authorization law to require? Either one of you.

**STATEMENT OF DOUGLAS R. COOKE, ASSOCIATE ADMINISTRATOR, EXPLORATION SYSTEMS MISSION DIRECTORATE, NASA**

Mr. COOKE. Thank you, Senator Nelson.

Also, before I get started, I would like to thank you for your very kind remarks. I certainly appreciate your leadership and incredible efforts to work with your colleagues and staff and the administration to pass the Fiscal Year 2010 Authorization Act.

The Authorization Act laid out an approach to a heavy-lift vehicle and a crew vehicle, which we, honestly, have taken very seriously with an expiration, and have been working on it since the Act was signed. We have decided on a reference design vehicle that was called out for in the Act, which are Ares and Shuttle-derived, for the launch vehicle. The crew vehicle, the MPCV, or multipurpose crew vehicle, reference design vehicle was chosen to be the Orion spacecraft that we have under development at this point. So, those are our reference design vehicles. We are working with those in, I believe, accordance with the Authorization Act. We have teams in place that are putting more detail on those designs.

We're looking at alternative designs to challenge and/or validate those concepts. We think that's appropriate, in order to be able to answer the hard questions that we'll undoubtedly have to answer, in terms of our final selections.

So, we are moving ahead. We actually have sent up notifications now for program offices for the crew vehicle, MPCV, at Johnson Space Center; and the heavy-lift vehicle, at Marshall Space Flight Center; and a commercial crew office, at Kennedy Space Center. So, we are moving it out. We also have procurement teams that are looking, in detail, at the contracts that we currently have for Ares–1 and for the Orion Spacecraft, and mapping those requirements to understand the scope of those contracts and how our existing work fits, or doesn't. We have been through, on the crew vehicle, working with procurement and legal, and have a procurement determination that the MPCV is within scope of the Orion contract.

So, I would say that we are moving with all haste, in my view, to try and get to final decisions and designs, making sure we have efficient contracting approaches, making sure that we are looking at efficiencies down the road. It is a constrained budget environment, so it's important that we look at all the possibilities for gaining efficiencies in our programs and projects. We're looking at the oversight models for these contracts, so that we don't have more people overseeing the contractors than necessary. It's going to be more of a risk-based approach.

Senator NELSON. OK, let me just stop you here. I want to get to more specifics.

Mr. COOKE. OK.

Senator NELSON. Do you understand the authorization law to say that you should start designing in the range of 70 to 100 tons that is evolvable to 130 tons?

Mr. COOKE. Yes, sir.

Senator NELSON. OK.

Mr. COOKE. And——

Senator NELSON. Then why do we hear commentary—and is it a misstatement—that NASA cannot afford to build a rocket with the capability of 130 tons, when, in fact, that's not what the law says? The law says that you start and that becomes evolvable, which is what you've just testified.

Mr. COOKE. Yes. Our approach is that we are looking at an evolvable design, starting in the 70- to 100-metric-ton range, that's called out in the Authorization Act, which is appropriate for first steps. That is evolvable, ultimately, to 130 metric tons. We are working through understanding how that fits, in terms of cost-phasing over the years, in order to develop that initial capability and then evolve it. Based on our own studies, a fairly natural progression, in terms of developing that capability. So, I can tell you that our teams are approaching it that way.

Senator NELSON. Well, it's been reported to have been said by the agency Chief Technologist, Bobby Braun, that the development of a heavy-lift capability will not be available for a decade. Now, that's not consistent with what you've said right here, nor is it consistent with discussions with the Administrator.

Mr. COOKE. I can tell you what the teams are doing, that are actually doing the work on this, they are working within the budget guidelines that we have, in an integrated way, between the crew vehicle and the heavy-lift vehicle, to map out a program plan of budget and schedule to develop these capabilities, both of them, in an evolvable way, to get to the earliest possible dates on flying. They're not finished with that work, so I don't have a date to give you. But, I can tell you that they are working in an integrated fashion to come up with that earliest possible availability.

Senator NELSON. Mr. Gerstenmaier, do you have anything to add?

**STATEMENT OF WILLIAM GERSTENMAIER, ASSOCIATE ADMINISTRATOR, SPACE OPERATIONS DIRECTORATE, NASA**

Mr. GERSTENMAIER. I think Doug described it pretty well.

We're working very hard to make sure we have a credible plan to go forward. It's taking us a little time for the teams to get together and integrate, to make sure that we've got a program that can deliver and meet the budget constraints that we understand that are out in front of us. So, we're not doing this lightly. We understand the Authorization Act. We think it gives us a good guidance. The teams are fully moving in that direction, and will be ready to update the report in the spring/summer timeframe, and give you the latest outcome from the report or from what the teams have done over the past several months.

Senator NELSON. Well, let me ask you this. Now, we've talked in more generalities here. I want to know how soon can you be testing the initial heavy-lift capability with the proposed funding levels?

Mr. COOKE. That is the subject of our current studies. They are working toward getting a date. They are trying to get test flights as early as 2016, but that remains to be finalized and worked in a integrated fashion. But, they are trying to get to a date of that timeframe.

Senator NELSON. When do you think you'll have that answer?

Mr. COOKE. We plan to update our report as Bill said, in the spring/summer timeframe. We have to get through a series of decisions and our procurement approaches in the next couple of months to be able to do that.

Senator NELSON. Senator Hutchison?

Senator HUTCHISON. Let me just put a fine point on the first series of questions that the Chairman asked. And that is—one of the things I said in my opening statement, is that it doesn't seem like the contracts are being modified to address the law that uses the technologies that we have, taking the next step forward. But, it is our understanding that you received a general counsel opinion from NASA that said that you could, without violating any prohibitions on new starts, move forward, setting up the program offices and starting the implementation of the law. And it is further my opinion that you now are setting those offices up.

This is my question: Are there any legal impediments, in the minds of those of you who are running the operations at NASA, to your moving immediately to the modification of useful contracts, initiation of aggressive vehicle design efforts for the heavy-launch vehicle, and other requirement of the Act?

Mr. Cooke or Mr.——

Mr. COOKE. As you said, we are setting up program offices, and we have the notifications up here. I think the time is almost up for that timeframe. In terms of the specific contracts that we have, for instance, on the crew vehicle, MPCV, we have changed and scaled back some work on that, partially due to budget, but also, as we do that, we are focusing it toward where the future lies, in terms of the Authorization Act.

In terms of the existing contracts for Ares–1, which includes the first stage, upper stage, and avionics unit, and J2X engine, we are progressing on those and focusing that work on work that would apply to heavy-lift vehicles. It is a little different, in that it was going from a lower-performance vehicle to a heavy-lift vehicle. But, we have focused efforts on those contracts to be as specific as possible to this future of a heavy-lift vehicle.

Senator HUTCHISON. Am I to take, then, from your answer that you are—where the contract is one that will be ongoing, but with modifications, that you are beginning to make those modifications, so that you will keep your experienced workforce going to the next transition vehicle or launch system?

Mr. COOKE. We are, at this point, focusing those in that direction. We still have to come up to agency decisions, in terms of final procurement regulations on how we would make the set of acquisition decisions for a heavy-lift vehicle, and would then have to apply those specific contracts for Ares–1, if they can apply to that vehicle, provided that that is where we get to in those decisions.

There are a number of things feeding that decision. And that is that we are assessing those contracts for whether or not the cur-

rent contracts have this new capability within scope. So, there is a significant effort on understanding that.

There are also studies that we have at Marshall Space Flight Center looking at alternate concepts that will either validate or challenge this approach, one of which is looking at LOX-Rp engines, one is looking at what we call a modular approach.

We also have industry participation and study contracts that we have had out on the street and that they have been working to over the last few months. They're 6-months contracts that will help advise us to make sure that we get to a decision of cost-effective vehicle, making sure that we have the input and assess those inputs from, not only our internal teams, but industry teams, as well.

So, we have not gotten to final decisions on the acquisition on the heavy-lift vehicle or the crew vehicle, because we need to understand how these current contracts apply, whether that is the best value for the American people and the government; and we need to understand the phasing of those contracts, in an integrated sense, within the budget constraints that we see.

So, I hope that is——

Senator HUTCHISON. Well——

[Laughter.]

Senator HUTCHISON. I'm trying to get a—just a clear answer to whether you are going in the direction that the law asked you to go, or actually told you to go.

[Laughter.]

Senator HUTCHISON. And are you doing that? And are you doing it in a timely way?

Mr. COOKE. I believe that the work that we have ongoing is headed in that direction, for those specific contracts we have underway. We have not gotten to the final decisions on the final design of the heavy-lift vehicle.

Senator HUTCHISON. But, you're moving along the——

Mr. COOKE. Yes.

Senator HUTCHISON.—lines that the law requires. I'm not——

Mr. COOKE. Yes.

Senator HUTCHISON.—saying you have to——

Mr. COOKE. I believe so.

Senator HUTCHISON.—have designated——

Mr. COOKE. Right.

Senator HUTCHISON.—who your final contract is going to be with. Obviously, you have all the procurement issues there.

Mr. COOKE. Right.

Senator HUTCHISON. But, are you moving toward the type of use of present technology, but with the further mission, beyond the present one, of using our technology but also being able to adapt it later for beyond-Earth orbit, and all of the relevant pieces of that?

Mr. COOKE. As I understand your question, I believe we are.

Senator HUTCHISON. Thank you.

My time is up, Mr. Chairman. Let me ask one other question.

And that would just be: Are you satisfied that—after the April Shuttle, that we will then move on to the last one, that is now scheduled for June, to finish the delivery of everything that we believe will be needed for the International Space Station? And the

equipment that we will need for it, and any of the other pieces, in that June mission, that we're going to need for repair and whatever it will take, over the period that we are not going to have Americans being able to go in shuttles?

Mr. GERSTENMAIER. Yes. We're moving out fully to support STS–135, as you've described, from a manifest standpoint. We've identified all the cargo that we need to carry on that flight. We're starting to identify what cargo we might return from Space Station, because that's a critical capability we'll lose temporarily, when the Shuttle goes down, until the new commercial providers come online. So, we're moving out for that mission. The only concern is that, if we got a significant budget cut somewhere here in the CR activity, that could potentially cause some concerns for us to execute that flight, just from a budget standpoint. Unless we get a pretty dramatic budget cut, we plan to go execute that mission.

We see that mission as extremely critical to us. What that mission provides for us is, it gives us some margin that, if the commercial providers are a little bit late, and they don't fly in late 2011 and in 2012, as they've been planning, then we've got some time, through 2012, that we'll have enough supplies pre-positioned on Space Station that we can continue to do quality research, we continue to keep our crew size at six onboard, stationed through that period of 2012 all the way until 2013. If we don't have that Shuttle flight, then it's absolutely mandatory that the commercial cargo providers come online at the end of this year and early into 2012. I don't think that's a prudent strategy. We need some margin.

Even in a shuttle world, we thought we understood where we were going to go fly, then we had the tank problem that slowed us down a couple months. I would expect small problems to show up in a commercial provider's side, as well. We need some margin to do that, and that's the criticality of STS–135 for us. It provides us, essentially, that 1 year of margin that can really make or break the critical research onboard Space Station.

We really want to get to where we're utilizing the Station as a full-up research facility, getting the most out of the crew, the most out of the research we've got on orbit. And to do that, we need to get the Station resupplied with the Shuttle while we can use that asset, and then we can let the commercial providers come online throughout the period of 2012 and into 2013.

Senator HUTCHISON. Well, thank you very much, because that allays my concerns, to a great extent. Because this—if we aren't going to use the Space Station, we have thrown a whole lot of money away and we have let down our allies, who have made significant contributions to the Space Station. And it was a concern of the Chairman's and myself, both—that we weren't going to fully stock it. And, in fact, the payload that we're taking up in April, the spectrometer, was something that we insisted on, in the previous administration, with the previous Administrator. And so, I'm very pleased that we're going to take that, because I think it has great potential for research. And then, beyond that, we just have to stock so that we do address the eventuality that you have addressed. It's just not good policy not to.

Let me just end by saying that, I believe that the sentiment on the Hill now is that this would be the last temporary continuing

resolution that we will pass, and that we must go to the long-term continuing resolution that takes us through the end of the Fiscal Year, so that you know what you're going to have to spend, so that the Department of Defense knows what it has to spend. And I think there are certain areas of our budget that we cannot allow to continue to go in 2-week increments. It's just not feasible. And certainly, NASA is one of those that, I have been bringing up repeatedly, must be in a long-term CR. And that must be the next one, after this 3-week one that is before us.

So, I do thank you very much.

And I thank you for indulging me a little beyond my time.

Senator NELSON. And again, Senator Hutchison, thank you for your continued vigilance throughout this process.

And thank you, Mr. Gerstenmaier, for a very clear answer about the cargo of STS–135 and the importance of that last Shuttle flight.

Senator Boozman.

Senator BOOZMAN. Thank you, Mr. Chairman.

And again, thank you, Mr. Cooke, for your service to your country in so many different ways.

I'm a little confused that in talking about this, we're talking about long-range plans in reference to the budget. Are you referring to the administration's budget, or are you referring to the guidelines that were submitted by the authorization bill that became law that everyone worked so hard to get done?

Mr. COOKE. Actually, we are looking at the budget request that came out this year, as we study these approaches. We're also looking at a more unconstrained way, in terms of budget, to show more or less how early these kind of capabilities could be brought online.

Senator BOOZMAN. But, in the questions that you answered, again, were you talking about the President's budget or the proposed authorized budget that's in law?

Mr. COOKE. We are looking, in these studies, at the President's requested budget. We are looking more broadly than that, at what it takes beyond that in an unconstrained sense, in terms of dates and that sort of thing.

Senator BOOZMAN. So, again—so, you're looking at it in terms of the President's budget, versus what the authorization is, in regard to my hearing the answers to your questions.

Mr. COOKE. That is a primary objective of these studies, yes.

Senator BOOZMAN. So, who changed the budget? Who made that decision?

Mr. COOKE. Obviously, the budget that is in the request is in request and we have the Authorization Act. And I think the answers that we'll have will answer to each.

Senator BOOZMAN. When was it changed?

Mr. COOKE. The point at which we started to study the President's request was when we received that, when it was rolled out.

Senator BOOZMAN. Well, I assume that you guys had input prior to that.

Mr. COOKE. We did work back and forth in terms of impacts of various approaches. So, yes, we were aware of that process.

Senator BOOZMAN. In recent testimony before the House, Administrator Bolden stated that—meeting the 2016 deadline for less—for the space-launch system and the multipurpose crew vehicle,

was difficult to get done. But, then he went on to say that he wasn't saying he couldn't do that. For the Fiscal Year 2012—2012 request, it has $1.3 billion less than the amount authorized for the two systems. It seems to represent a self-fulfilling prophecy. Is there any way that you believe that you could actually meet the 2016 contingency availability of the systems at the funding levels projected in the Fiscal Year 2012 request?

Mr. COOKE. We are still working that, sir. That is what will be a part of our results later this spring and summer. As a part of that effort, in terms of stating whether we can or can't meet the 2016 date, the wording that we had in our initial report talked to whether or not we thought we could meet that date. When we talked about it there, we also qualified that by saying that we realize that it was important that we—let me just step back. When we talked about that, that was our initial study, based on conventional development approaches and costing methods, and we said that in the report. We realize that, in moving forward, we need to come up with more efficient approaches to how we develop these space vehicles than we have in the past.

We have significant efforts in understanding oversight models, supporting infrastructure needs, the right level of requirements to put on contracts, a number of other areas specific to trying to get costs down. So, that would lead you to, probably, a different estimate, in terms of availability date. If we can get efficiencies, that tends to bring the date back to the left.

So, those are the kind of things that we put a lot of effort into understanding. And we don't have the results of that yet, but we're trying in earnest to get dates as early as we can with those approaches.

Senator BOOZMAN. Thank you, Mr. Chairman.

Senator NELSON. Senator, those were excellent questions.

You all are constrained, you're conflicted because you've got to defend the President's request and yet there's a law, and it's called the NASA Authorization Act of 2010. And the two are in conflict. And the President's budget is not going to be enacted. And we're trying to get from here to there, and stop this $600 billion cut that the House came forward with, which, as you said Dr. Whitlow, was over 800 jobs, it's a little less—that was at Johnson—cut; Kennedy, almost the same amount. We even missed the 816 jobs cut at Goddard Space Flight Center. We're trying to get from here to there, and the two are in conflict. And the President's budget is not going to be passed in this Congress. So, you all have got to help us get there.

Senator Rubio.

## STATEMENT OF HON. MARCO RUBIO, U.S. SENATOR FROM FLORIDA

Senator RUBIO. I just want to build on what the—what Senator Boozman's asked already, and maybe phrase it a different way; but, it's the same question. I think what the Senator was getting at, we have this interim report that basically says, "Look, with the amount of money you guys have given us or the amount of money that we have, we're not ever going to be able—we don't think we

can build this by 2016, although everyone's saying that we want to build this by 2016."

And then we get a recommended budget, from the President, that actually cuts it even more. So, I think what, one a bigger level, what we're really—I think the question really is, you know, what is the level of commitment to getting this done at anytime in the near future? Because, certainly these budget requests are statements of vision, or lack thereof. And so, my—I mean, the—and obviously, you're in a difficult position, or you're in a unique position, I suppose, of having to both speak on behalf of what the agency's vision is and, at the same time, having to explain the President's budget. But, we look at it, at least I do—I mean, this is—I've only been here a few weeks, but it didn't make a lot of sense to me that you're saying you're trying to get something done by a certain period of time, and the money you already have dedicated to it is now not enough, but we're going to cut it even further.

And I think that's really what the question goes to the heart of. And so, I mean—I guess my question is, How serious is NASA, and is this administration, about building these programs?

Mr. COOKE. I believe NASA is serious about building these programs. The questions that you ask end up being questions of priority and policy that are decided at different levels. I can tell you that the people that work at NASA are amazing in their drive to implement under the constraints and direction they're given. We have a tremendous workforce that will work tirelessly and commit to doing these programs within budgets, and they'll find the best ways to do it. So——

Senator RUBIO. But, you would agree that——

Mr. COOKE.—that's where we are.

Senator RUBIO.—I mean, you would concede that we get a report saying, "The money we have is not enough to finish it by 2016," and then a budget comes out that says, "We're going to cut that inadequate budget even further"—you would concede that there is a conflict there, at least certainly in terms of what it would appear like.

Mr. COOKE. Well, there's certainty in what you say, the budget request, it is less. There's no doubt about it. It's numbers that are written down. This is a matter of balance and priorities, and it's a NASA priority to develop commercial crew transportation to and from Earth orbit. So, it's a question in policy, I believe, of where you draw that balance. All I can tell you is that the folks that work for ESMD in human spaceflight will endeavor to develop the systems, and want to develop these systems, within constraints that we have. We always do that.

Senator RUBIO. Well, again, I don't—never question the professionalism of the folks at NASA, who do a phenomenal job. I would just say that, from our vantage point, priorities on paper is one thing, what an administration is willing to put its name behind is something else. And when they issue a budget that cuts the funding of a so-called priority, obviously people are going to ask questions.

I wanted to—quite frankly, people are going to doubt—I mean, that's the bottom line—that that truly is a priority, when you're cutting funding to it, like this President's budget does.

Kind of an unrelated topic, something I was asked about earlier today, minutes before coming here. There was a Government Accountability Office report from 2007 and 2009 that cited NASA losing track of its equipment, more than $8.7 million of equipment, in the past 5 years. Could—can you comment, or anyone comment, on what's been done to—are you familiar with that news account? And, if so, can you comment at all what steps that have been taken to prevent that from happening in the future? If you haven't read that news report, or what have you, (a) that's problematic, and (b) I probably need to share it with you. I was just asked about it. Moments ago, I was handed a copy of it. Is anyone familiar with that?

Dr. WHITLOW. Yes, we are familiar with the study that's been done to track our equipment. $8.7 million is a significant amount; a very relatively small percentage of our total assets, though. So, what we're doing is, we have been implementing programs and efforts to do better tracking of our equipment, and know who signs them out, who owns them, who they're assigned to. We're making every effort that we can to reduce that.

Senator RUBIO. What kind of equipment more or—because it didn't specify—what kind of equipment are we talking about?

Dr. WHITLOW. Some of it includes——

Senator RUBIO. Obviously, not a rocket. But, I mean, you know.

Dr. WHITLOW. No. Some of it includes computer equipment and other relatively small things. But, over an agency our size, they add up to a number of the size that you mention.

Senator RUBIO. So, there's—have steps been taken, specifically in—as a result of this report, to prevent that from happening in the future?

Dr. WHITLOW. I'd have to take that for the record and get you specific steps that are being taken across the agency.

[The information requested follows:]

NASA is strongly committed to its responsibility to the American taxpayers for the stewardship of government property. While the Agency consistently stays below its own internal property Joss benchmark of 0.5 percent property loss and well below the accepted ASTM International commercial industry standard of 2 percent, NASA continuously assesses people, process and technology improvements to minimize property losses. Some of these recent efforts to help improve our property management accountability include revisions to NASA's Equipment Management Policy; establishment of monthly meetings with Center equipment managers to monitor recoverability and corrective actions plans; upgrades to the property management system to enhance the computation and rationale behind an identified loss; educational outreach initiatives for the workforce regarding property accountability awareness; and logistics reviews at NASA Centers to monitor equipment accountability processes and procedures.

NASA is also implementing a new policy that will strengthen and enforce user accountability for equipment loss to include: (1) providing guidance on the minimum level of care NASA expects employees to exercise over equipment and the circumstances under which employees will be held accountable for equipment loss; (2) strengthening NASA's accounting for electronic storage devices that contain NASA information or other electronic devices costing less than $500; (3) requiring that all packages sent through central receiving are opened and tagged accordingly-regardless of whether they are procured through a purchase card or purchase order; and (4) establishing and enforcing property management training requirements for all personnel involved in the use, stewardship, and management of equipment, including end users, central receiving warehouse personnel, purchase card holders, and property custodians.

NASA has taken specific actions to mitigate the risk of property loss across the Agency. The following specific actions focus on the areas of people, process and technology:

**People**

*Pursue the availability and application or mission funds to endorse the training and education of equipment management personnel across the agency.* This successful approach enabled stakeholders to enroll in webinars hosted by the National Property Management Association, NPMA. Over 150 personnel attended courses such as: Actions to Reduce Lost Property, Managing Electronics Disposal, Applying Industry Leading Best Practices, and lately, the enrollment of 7 personnel to attend a National Education Seminar hosted by NPMA.

*Development of a quarterly Equipment Management Newsletter* to provide the latest business practices on equipment management, from acquisition to disposal, and to keep stakeholders across the agency informed of the latest innovations and initiatives affecting the equipment management program, *i.e.,* physical inventory procedures, the calculation of equipment loss rate, updates to GAO recommendations, trading-in equipment, pre-inventory activities, etc.

*Development of an Equipment Management Training Video.* NASA has reinforced efforts to achieve equipment control through enhanced viewing of our newly developed property management video which stressed the importance of property accountability and the day-to-day management of NASA property. The 14 minute web-based video is available in SATERN and was broadcasted via internal NASA television. The video introduces the ability to provide visibility of total property assets and encourages the use of the property management system. In addition to the video, continued communication with property personnel occurs via video conferencing and teleconferences. All forums stress the benefits to NASA of personal property reutilization and the value of the Personal Property & Equipment system.

*Development of the Equipment Management Program Website.* This website, within LMD, provides a description and/or definitions of the purpose, program objectives, program and individual responsibilities, as well as links to governing NASA policies and other functional links that offer useful guidance and information on training opportunities to the equipment management community across the agency.

**Process**

*Compensating Controls Review Program (CCR)* which evaluates the performance of NASA Logistics Operations and provides an assessment of center compliance with Agency policy and procedures. The current review approach was established as a direct result of General Accounting Office (GAO) and NASA's Inspector General (IG) audits. These external audits identified some of NASA's property and equipment management areas lacking sufficient controls and requiring corrective actions. Therefore, the CCR process was instituted to evaluate the adequacy and consistency of Agency policy execution and procedural compliance with NASA guidance on equipment, disposition, and contractor property, among other areas.

*Baseline Performance Review (BPR)* is the Agency's forum for performance management of its programs/projects and mission support functions and is results-oriented. The BPR serves as NASA's senior management monthly review of performance integrating vertical and horizontal Agency-wide communication of performance metrics, analysis and independent assessment. The BPR encompasses all mission activities including the equipment management program and other logistics functions. The forum is designed to be actionable, supporting the Agency decision-making councils.

*Continuously review applicable governing NPDs and NPRs to strengthen or update current business practices.* The continuous review of equipment management regulations aims to reinforce existing policy and to ensure adherence to Federal regulations. For instance, the Logistics Division will strengthen and enforce NASA's policy on equipment wall-to-wall physical inventory by transitioning from triennial to annual inventory campaigns starting in FY 2013, as well as the revision of the annual walk-through inspection, and the policy regarding retention of inactive equipment, among other areas.

**Technology**

*Completed a Case Analysis on the potential application of Radio Frequency Identification technology (RFID).* The Agency investigated the potential application of RFID technology to manage its personal property. LMD staff contacted various Federal Agencies to gain from their lessons learned and engaged in a research concluding that an RFID implementation has the potential to reduce inventory cost, reduce equipment loss, and enhance equipment accountability. The study was completed on March 31, 2011, and, based upon this research; the assessment also identified areas of concern regarding the implementation of RFID technology.

*Enhancements to the Personal Property and Equipment (PP&E) System.* The continuous review of system capabilities and features enables stakeholders to identify

system shortfalls and develop remedies to better support policy changes, enhance data accuracy, and to accurately generate reports, *i.e.,* equipment loss rate formulas, equipment recoverability reports, etc.

*Development of the Personal Plant and Equipment (PP&E) Executive Dashboard.* The Dashboard will provide the oversight of data elements extracted from the PP&E system and Business Warehouse databases. The Dashboard will allow senior officials and the Equipment Program Manager access to total asset visibility and the generation of Ad Hoc real-time reports with the purpose to identify trends, strengths and weaknesses in the performance of equipment management functions across the agency.

Dr. WHITLOW. But, we take it very seriously, and we are starting to implement different efforts as I mentioned, to reduce that number toward zero.

Senator RUBIO. OK, thank you.

Thank you.

Senator NELSON. Mr. Gerstenmaier, let me ask you a softball question.

[Laughter.]

Senator NELSON. I've heard it characterized a lot that commercial capabilities and the heavy-lift development have been portrayed as an either/or capability for NASA. The authorization law says that we need both. Do you think we need both?

Mr. GERSTENMAIER. Yes, I think it's clear that we need both. We need the expiration larger-class rocket to do the things beyond low-Earth orbit, to build and launch the spacecraft to go to the further destinations well beyond low-Earth orbit. Then, we're looking to use both commercial cargo—as I described, we have existing service contracts in place to resupply the Space Station as the Shuttle is retired, so those commercial cargo contracts are in place with two companies, SpaceX and Orbital Sciences Corporation—and then we're looking at a new commercial crew transportation capability which would also augment the capability we lost from the Shuttle. We need that, again, to reduce our reliance upon the Russians for crew transport.

So, the answer to your question is, really, we need both. That's the struggle we have in the budget is how we balance those two back and forth, and how we get that right mix between what we need in the commercial activity and what we need to do the exploration, to meet the priorities that we're being asked for both of those. Both of those have near-term desires to fly as early as we can. That would imply moving money back and forth. What we're trying to do, and what Doug tried to describe to you, is how we try to balance those with the programmatic guidance we get through the Authorization Act and here, through the administration.

Senator NELSON. Well, that is a very well-stated answer. And I think that that's genuinely the policy that was set out in the authorization law. And I think that's genuinely the policy that NASA is trying to implement. And yet, the report that came in January is interpreted by some as saying that NASA cannot build a new heavy-lift launcher and the capsule, as prescribed in the law. And much of the time has been discussed about what NASA can't do. And I'd like to hear your thoughts on what NASA can do and what you're already doing toward the implementation of the authorization law.

Mr. GERSTENMAIER. Earlier, I think Doug described that pretty well. We've got some teams set out with a base configuration and at least two other configurations to go look at alternate concepts of achieving the goals we just described, the heavy-lift launch vehicle and to maximize, as you discussed earlier, what we've already done in the Orion capsule, to make sure that that carries forward. So, we've got those teams off, working.

We also, Doug's team, put out some requests from industry to get their ideas that were not constrained by any of our previous thoughts so we can get the best ideas from industry. Doug's teams are sitting there, as Doug described, trying to integrate all those activities.

We're trying to take a look at the existing contracts we have in place to see if those contracts are applicable in the new work that we want to go start. We have certain legal requirements. We can't take a contract that was issued for one purpose, and apply it to a different purpose without going through all the right legal checks to make sure that's an appropriate use to extend that contract. As Doug described pretty clearly, we need to get the best value out of that to show that that is the most effective manner to do this procurement activity.

The teams are working through all those things. Our intent is that, by the time we get to late spring, early summer, we will have enough of this completed that we can give you a definitive answer in our follow-on report about where we head with this and what we understand is available and what's possible as we move forward.

So, I will tell you that, as Doug's described and you've all described to us, is the NASA team definitely has a can-do attitude, if we lay out the right constraints. The authorization law gave us those constraints. We understand the President's budget, as well. We can factor both of those in as considerations. And the teams are fully running and implementing, as fast as they can, to put together a sound plan that's affordable and sustainable and realistic that we can present to you in the late spring, early summer.

Senator NELSON. Well, with the new heavy-lift capability, you're the expert, tell us: What about the new destinations that are enabled by the evolvable new heavy-lift capability? What does the Nation stand to gain from that exploration?

Mr. COOKE. I can address that.

With the kind of capability that's laid out in the Authorization Act, 70- to 100-metric-ton evolvable to 130 metric tons, we can incrementally be able to go to numerous destinations that are of high interest.

It could be cislunar space. It can be at LaGrange points between the Earth and Moon, where we could repair telescopes; we can stage missions to the Mars vicinity, potentially. It would get us missions to the Moon, with additional capabilities. We can go to near-Earth asteroids. We can go to the moons of Mars, which may be an interesting step in this progression.

All of these places hold incredible information that we probably don't even have a clue as to what we'll find. Every time we go explore, as great nations do, we learn, and we learn things we didn't

expect. And those are certainly all incredibly interesting destinations.

The Moon, itself, is a place that we know much better, now that we've flown the lunar reconnaissance orbiter, that our organization put up and now is being run by the Science Mission Directorate. But, we've learned more about the Moon than we knew during Apollo. Mars has always been a premier destination for our future human spaceflight. And there's incredible science and understanding that we can bring back, in terms of evolution of that planet, whether or not there's life on that planet. The opportunities are incredible.

And the heavy-lift vehicle that we've talked about, and the crew vehicle, are the critical first two steps to any of those destinations. Those are incredibly important for where we go from here. There are additional capabilities that will need to be developed to do these missions, but those are two essential steps that are laid out for us and that we're interested in developing and pursuing.

Senator NELSON. Thank you for that answer. I think that gives everybody a vision. You've got to get up there, with humans and components. Who knows what the technology—by the time we're ready to go to Mars with humans, we might have new technology that takes us there in 39 days, instead of the 9 or 10 months, which could redo the whole mission.

So, thank you for that comment.

Senator Boozman.

Senator BOOZMAN. Thank you, Mr. Chair.

In the past year, there have been two failures of the payload faring mechanism for the vehicles launching the orbiting carbon observatory, and recently, the Glory mission. This has resulted in the loss of these important payloads, both expensive and highly capable satellites.

Two things, Mr. Cooke: Do those losses impact your view of the maturity of the commercial companies currently involved in the commercial orbital transportation system program to deliver cargo to the International Space Station? And are these failures viewed as normal growing pains, or do they potentially affect the design, manufacturing, or vehicle processing failure?

Anybody. Whoever's most qualified.

Mr. GERSTENMAIER. Yes, I think I'll answer those. I'm responsible for the launch services program.

First of all, the failure was something we didn't expect, on the Glory spacecraft. When we lost the OCO spacecraft, we go into a very rigorous mishap investigation board to understand exactly what happened on that loss, why the fairing didn't separate. We chartered an independent team that went through all the potential failures that could have led up to that.

They gave us a series of recommendations. One of the areas that was the most likely cause of that failure, on the OCO spacecraft, was a system that pushes the fairings apart. It was a hot-gas system. Essentially, you ignite a solid propellant; it generates gas and pushes the two halves of the fairing apart; you know, much like an airbag expands in your car.

We replaced that system with a cold-gas system on the Glory spacecraft. That was a much more reliable system that we thought

would operate much better. We went back and the mishap board had a series of recommendations, probably 50 or so recommendations of things that needed to be changed in the fairing system. We went through methodically and made all those changes. So, when we had this Glory failure, it was a total surprise to us. We worked as hard as we could to make sure that this failure would not repeat, and, for some reason, it repeated.

We now have a new mishap board looking at it. It's too early to speculate on what the failure was the second time. But, we need to go through it methodically, understand what failure occurred, and then, more importantly, understand what we missed in our process. What did we miss from the first failure to this second failure that caused us to have a repeat failure? This is unacceptable to us, to have a repeat failure. You know, we spent a lot of time and effort making sure it wouldn't occur. And we obviously missed something. It shows how difficult our business is. I think it shows you how much we push the envelope, in terms of spaceflight, that things appear simple, and they're not simple. You know, we're using the state-of-the-art engineering, state-of-the-art systems that are really at the limits of what we can do, and we need to be extremely careful.

So, that implication doesn't cast any doubt on the commercial providers for ISS, but it tells us that we need to be mindful that it's not an easy industry. As I described to you earlier, when I wanted the STS–135 mission for extra cargo, that is specifically to provide some margin so we're not putting too much pressure on that commercial industry, forcing them to deliver on a schedule that's not realistic, forcing them to cut corners to try to deliver on a certain data, and then have a failure which loses cargo to us. That would be totally unacceptable.

So, this Glory failure, to us, is an example of how hard our industry is, how tough it is, no matter who's doing the work, whether it's NASA or whether it's a commercial company, whether we're following oversight of a company, like Orbital, that manufactures the two vehicles for OCO and Glory. We just need to watch that process and do due diligence to make sure we deliver quality spacecraft when we do that.

Senator BOOZMAN. In closing, Mr. Chairman, I appreciate your leadership in this area. And again, as Senator Rubio said, being new to the process this has been a good hearing.

But, I think the thing that concerns me is that, last year, as a Member of Congress and not directly one that was at the negotiating table, to get an authorization bill that, at the end, I think most people felt like was a fair compromise, to go forward, that would put us in a good position. And you all were very much involved in that process, through your expertise. And now we have a budget that's come back that simply does not reflect that negotiation, that authorization bill. And so, you have, in a very bipartisan spirit, much concern about that.

And my concern is, is that we're going to mess around, and the President's Budget bill will not get done. Senator Nelson made that statement. I agree with that. And then we have a situation where we muddy the waters and then nothing gets done and we're in limbo, now, for another period of time. So, I hope that we can reach

agreement and then get back on track with the authorization that we agreed to, as we go forward.

Thank you, Mr. Chairman.

Senator NELSON. Senator Rubio.

Senator RUBIO. Thank you.

Before my final question, I—and I don't know if you've talked about Mr. Vanover. You know, we've had a—Mr. James Vanover was a 53-year-old swing-arm engineer for NASA, for contractor United Space Alliance. And he fell from launch pad 39-A at the Kennedy Space Center, in Cape Canaveral, while working on the Space Shuttle Endeavor, and died. And so, our condolences to him and to his family. I know Senator Nelson shares in that, as well as Senator Boozman. He worked at the Kennedy Space Center for 28 years. And his service to our country doesn't go unnoticed. I did want to say that today, for the record.

But, let me ask again—all of this, this is an enormously important agency and program for our State. And it's our first—my first hearing as a member of the U.S. Senate, with regards to these issues, so I wanted kind of summarize, in my mind, the status of where we are and ask what I think is an important question, and maybe it's already been answered. And, if it has, I apologize. But, clearly we're closing down the Shuttle Program. We walked away from Constellation. And no one can tell us when we're going to have a replacement for any of these things, but we know it's not going to be 2016, so it'll be sometime after that, whenever that is. And so, we'll be totally dependent on the Russians, basically, at the tune of—what is it—$16 million per seat, to be able to access our investment in the International Space Station. I think it's probably the first time in four decades—am I wrong—in—first time in four decades that the United States—and maybe longer—will have the capability of launching, in a short amount of time, human space travel.

Has there ever been discussion about what contingencies there are available to us to access the Space Station if somehow the Russians are no longer available to us or no longer want to cooperate with us on—is there thoughts about that? Is that something that's been discussed within the agency? What we would do if we have this massive investment and need to service the Space Station, but somehow we weren't to access Russian travel any longer?

Mr. GERSTENMAIER. I would say that, from a technical standpoint, the concern is real. If you remember back when we had the *Columbia* tragedy on the Shuttle, and we lost the ability to transport crew for a period of time while we got the Shuttle back to flight, we were dependent upon the Russians, at that point, to deliver our crew to the Space Station. And that allowed us to keep a crew—and we had to reduce the crew size from three, at that time, down to two during that period, but that allowed us to continue. So, it's extremely important, in our business, to have dissimilar redundancy or have different transportation systems to get to Space Station. I think that's our biggest risk as we go into this period.

I don't worry about the Russians withholding services from us, because, in a sense, they're dependent for us also on Space Station. We have a mutual dependency. We provide attitude control for the

Space Station for the Russian elements that are up there. So, they need us to do that. Our systems also provide power now to the Russian segment, to give them power to their modules. So, they need our expertise and they need our astronauts to provide the maintenance of that—those systems, to keep those Russian systems functional. So, we have a mutual dependence. So, it's to their advantage to have U.S. crew members on board Space Station to help keep their facilities operating and keep the overall complex operating.

So, it's truly an International Space Station, with interdependencies between us. So, I don't worry about the—"political" may not be the right word, but the withdrawal of transporting astronauts, for whatever political reasons. We need each other.

What I worry about more is, Could we have a technical problem in their systems that take the Soyuz down for a period of time, that we would not be able to have access to the Station. So, it's clearly to our advantage to get a redundant transportation capability available, as soon as we can, to help with that robustness.

Senator RUBIO. So, your testimony sounds like you're less concerned about—and I think "political" is the right—that somehow some political conflict could somehow evolve into something that would affect our ability to work with them. You're more concerned about them encountering problems in their own system, them having some sort of technical inability to launch, the way we did, and therefore neither one of us could get there, basically.

What—how would you characterize the—and this, I guess, is to everyone—how would we characterize the capabilities—the Russian capabilities, from a technological standpoint? I mean, are they—is your concern one that is—obviously, anytime you're dealing with something of this magnitude and of this complexity, there's always the opportunity for a breakdown. But, do they have sufficient investment, and do we have sufficient confidence, in their systems to think that something like that is unlikely? Or——

Mr. GERSTENMAIER. You know, they are very committed to what they do in space. And they have a different approach to spaceflight than we do, I would say. But, they have a very robust approach to spaceflight.

When we increased the crew size on Space Station from three crew to six, which we did about a year ago or so, that required more Soyuz vehicles to be launched. So, they had to step up their production rate of Soyuz vehicles. And they were able to meet that challenge and continue. Also, when we increased the crew size—for them, they needed additional Progress vehicles, which are their cargo resupply vehicles; and they were able to step that up. They're also in the process of upgrading the Soyuz vehicles to a digital Soyuz. They were predominantly analog, an analog system to control the vehicle. Now, they're stepping up to a digital. So, they're making incremental mods and upgrades.

They work with us quite a bit; we share data back and forth, from a technology-understanding standpoint. They give us good insight into what they're doing. And I think they're very capable and very resourceful. And they're a good partner to have in space with us.

So, I don't doubt their technical capability; they're robust. But, I think, as you described and I tried to describe earlier, the business we're in is very technologically demanding. We operate on the edge in many areas. We're not like an aircraft that has extra performance and has engine-out capability, in some situations. We really need the most out of our rockets and our spacecraft. So, we've just got to stay vigilant. And they're doing a good job at that, but we could potentially have some breakdown that might interrupt service for a period of time.

Senator NELSON. Don't worry, we're going to get to the rest of you in a minute.

[Laughter.]

Senator NELSON. Mr. Gerstenmaier, the Inspector General has indicated that NASA is not making the best use of appropriated funds, given the continued restriction from canceling Constellation contracts, which besieges us in language that we're trying to get out of the continuing resolution. Is this prohibition compromising your implementation of the authorization law?

Mr. COOKE. I'll answer that.

Certainly, we would be happy, and less constrained, without the restrictions; however, as I had mentioned earlier, we are tailoring the work on our contracts right now, whether it be the Orion spacecraft or the Ares–1 rocket and its various contracts. We're tailoring that work to be as closely in line with the Authorization Act as we possibly can.

So, I think that we're doing a very good job of spending money wisely. We're making careful choices. That's being done down at the project levels and program level. When we get to the point of making final design decisions, I think it will be important to have flexibility to make the next moves. But, up to this point, I believe that we've been managing this pretty effectively. For instance, an example would be, if there's work that is a long-lead item for a heavy-lift vehicle, as well as what it would have been for Ares–1, we would continue that work. And if there's a new task that would be Ares–1-specific on an Ares–1 contract, we wouldn't do it or start it. So, we're making those choices.

Senator NELSON. How much money would you say that NASA has had to spend, since the authorize bill became law, by virtue of that provision in the appropriations bill requiring the continuation of Constellation? How much money has NASA spent since that authorization law that, otherwise, it would not have spent? In other words, how much has NASA wasted?

Mr. COOKE. I would have to take that for the record.

[The information requested follows:]

Providing a monetary estimate about how much work will feed forward, or providing an estimate about how much funding NASA spent since the passage of the NASA Authorization Act of 2010 that otherwise would not have been due to the prohibition on cancelling Constellation contracts in the FY 2010 Consolidated Appropriations Act is not possible, largely because the Administration has not made final decisions with regard to the design and acquisition plans for the new Space Launch System (SLS), as well as support elements for both the SLS and the Multi-Purpose Crew Vehicle (MPCV). Therefore, NASA cannot specifically say, at this time, which Constellation elements will or will not feed forward into the new SLS and MPCV programs, and as such, we cannot accurately estimate how much money could have been saved if not for the funding restriction.

We would like to note, however, that during this time period, NASA was making efforts to focus existing Constellation contracts on work that would likely feed forward to the SLS and MPCV programs—a fact that was recognized by the NASA Inspector General in a letter to Congress on February 2, 2011.

Mr. COOKE. But, I will tell you that I believe that's a small amount, for instance, we probably would have canceled the Constellation Program office work, for instance, but, honestly, they have reduced their support contractors, they have scaled way back. And actually, most of their work right now is aimed at helping to transition Constellation to what comes next. So, I don't have a number, but everything that we're doing is to spend our money efficiently.

Senator NELSON. Mr. Gerstenmaier, back on Senator Rubio's question. Could you quantify what you think is the likelihood, in numbers, that—once the Shuttle has flown and we're entirely reliant on Soyuz, the chance that Soyuz would not fly?

Mr. GERSTENMAIER. I can't give you a quantified number. I could work with our experts and try to get some kind of calculated number, but I don't have one that I could give you.

Senator NELSON. But, whatever it is, it clearly is in the interest of the U.S. Space Program—for that matter, for the Russians, as well; for anybody participating on the Space Station—it's clearly in the interest of getting an American launch system, not only for cargo, but crew, as well. And that's another reason that we're pushing so hard, in this NASA authorization policy that's been set into law, to go on and get it done. Get first done, under that law, the commercial capability of taking cargo and crew. And we'll see, at the end of the year, if we've got capability of cargo. And then, of course, to have the other—the heavy-lift, which is for a different purpose—but to have that as a backup, which was part of the stated policy in the authorization law.

Let me ask you, more specifically, with regard to the Kennedy Space Center, that the 21st Century Launch Complex improvements in the President's request were reduced when compared to the levels that were authorized in the NASA authorization law. And you all have been explaining that you've been moving some of your money around in order to take care of that. The GAO reported that NASA facilities, clearly, are in a degraded condition and in need of improvements, not just at Kennedy, but every place. So, if you would, please, explain the need to upgrade those facilities, specifically Kennedy's launch infrastructure, to enable the long-term exploration program to be optimized in order to reduce future operations cost. Can you share that with us, Mr. Gerstenmaier?

Mr. GERSTENMAIER. Yes. The plan with the funds to do the facility work down at the Kennedy Space Center are—we're looking, kind of, now at doing those as part of the—or heavy-lift launch system or the space launch system. So, we're looking to put some facility upgrades that will have to occur for the new vehicles we're going to fly out of the Cape, that Doug's teams are reviewing and analyzing. And that's a piece of it.

But then, we don't want to just make the facilities unique to that particular rocket. In the past, in the Vertical Assembly Building, the platforms that sit in there are at certain heights for one specific rocket that goes into the Vertical Assembly Building. They're

not generic, and you can't bring another vehicle in to go be processed there, without a dramatic change to the Vertical Assembly Building. So, the idea of these funds was to, not only upgrade the facilities, from a maintenance standpoint, but also make them more flexible for the future, that allows them to be used for multiple purposes.

Same kind of thing in the launch complex. Many of our control consoles and systems are geared to an individual rocket that is launching. They're not generic in nature. So, then, when you want to bring in another launch vehicle, you have to standdown range interfaces, reconfigure slowdown, it takes more time to bring the next rocket in. We can only launch about every 48 to 78 hours, because of range activities. We want more generic capabilities in place so that turnaround, from one rocket launch to the next rocket launch, is much faster. That helps the throughput, through the Kennedy Space Center.

So, we're looking forward-looking and doing what Doug needs for those near-term rockets, but we're not doing it solely focused on those near-term rockets. We're taking a broader look, to make sure that these facilities we put in place at Kennedy support a broader range of rockets, which ultimately allow a higher throughput, which allows a lower cost-per-rocket launch at the Kennedy Space Center, which is where we want to be in the future.

So, that's how we're using those funds to try to upgrade the facilities and modernize, posture ourselves for the future, and, by posturing ourselves for the future, support what Doug has on the books today, but as well as the future programs we see coming forward.

Senator NELSON. And, of course, some of the expenditures that have already been made, you can take advantage of. For example, how you've already reconfigured Pad 39-B. And that can be utilized for the future heavy-lift vehicle.

Dr. Whitlow, a flat-line budget is what we looking like, over the next several years, realistically, given this financial environment. And it's going to be critical, in that kind of budget, for NASA to change the ways of doing business that it has done in the past. And it's going to have to actively reduce cost.

Now, the authorization law requires a study that, and I quote from the law, "carefully examines NASA's structure, organization, and institutional assets, and identifies a strategy to evolve toward the most efficient infrastructure consistent with NASA's missions and mandates."

So, share with us what NASA is doing to reduce the fixed and operating base cost of the agency.

Dr. WHITLOW. Well, one of the things, as outlined in the authorization law, is we're supposed to come forward, within a year, with an integrated facilities master plan for the agency. We have already received the master plans for the centers, and we are integrating those so that we can provide the capabilities that the agency needs as we move forward. And our investments that we will make are consistent with NASA's strategies and plans. We're using these facility master plans to guide our investments.

Currently, there's a lot of Apollo-era infrastructure in the agency. Eighty-three percent of our facilities are over 40 years old, and a

typical design life is about 30 years. And so, our facilities are older, they're inefficient, and they're expensive to operate.

So, we have a strategy where we're going to become more flexible with our facilities, as Mr. Gerstenmaier said, become easier and more efficient to operate. We're going to modernize, over a 40-year period, so that, at the end of 40 years, we will have an in infrastructure set where 63 percent is less than 40 years old and, therefore, more reliable and less likely to have emergencies that could impact our mission.

Senator NELSON. So, your answer is, we're going to have a study?

Dr. WHITLOW. No.

Senator NELSON. And the study——

Dr. WHITLOW. Our answer——

Senator NELSON.—is going to be ready at the end of the year?

Dr. WHITLOW. The study will be ready at the end of the year. But, we are already using the elements of that study to guide our investments. And so——

Senator NELSON. OK. Give me some specific examples.

Dr. WHITLOW. Say, I'll tell you, between 2005 and 2010, we have disposed, either through demolition of old, unneeded facilities, or through excess of our facilities, approximately 750 facilities, valued at over a billion dollars. We're starting to replace our facilities with newer facilities, more efficient, more flexible, more energy efficient, and cheaper to operate. So, we are starting to have the strategy to build out, across the agency, an infrastructure that is more suitable to our mission needs, it's more efficient to operate, cheaper to operate, given——

Senator NELSON. OK. And the question is——

Dr. WHITLOW.—what everybody is saying.

Senator NELSON.—give me an example.

Dr. WHITLOW. I can tell you, for example, at the Glenn Research Center, we're excessing two older buildings on a plot of land across from the main campus, and we're moving those civil servants, who actually are outside of the main perimeter, inside the perimeter at the Glenn Research Center, and building a more efficient office building. We've recently opened a building at the Kennedy Space Center that actually produces more energy than it uses. We have a LEED Platinum Building, we recently opened at the Ames Research Center, that's energy efficient and cheaper to operate than our older infrastructure.

Senator NELSON. What are you all going to do with the facilities that have extremely low utilization rates?

Dr. WHITLOW. We currently have a process in place—our NASA Capabilities Forum—we're working with the mission directorates—Dr. Weiler, Dr. Shin, Mr. Gerstenmaier, and Mr. Cooke—where we're looking at NASA's plans and we're identifying those capabilities. And that—and capabilities of people as well as laboratories and facilities—that either we need for the future or we don't need for the future. If we don't need a capability for a long period of time, then the people will be retrained and/or reassisgned, and the bricks and mortar will be eliminated.

Senator NELSON. Well, NASA has some extraordinary, unique facilities, but a number of these facilities are not being utilized very heavily. And from the standpoint of NASA, say, for your local poli-

tics of closing some facilities at a particular center, since NASA's going to have to do as much as it has in the past, if not more, with flat line funding, you all are going to have to make these choices.

Dr. WHITLOW. Correct.

Senator NELSON. And that's going to be, in some cases, uncomfortable. And where it is a unique facility, you've got to prepare to carve out that unique facility, but it's got to be utilized more.

Things like wind tunnels. You know, the Air Force aeronautics—we're going to get to you all in just a second—aeronautics, so much is dependent on that. But, is it being utilized?

Dr. WHITLOW. For example, in aeronautics, we have, over a period of time, eliminated some of our wind tunnels. There's a wind tunnel at the Langley Research Center—and I think it's their 16-foot wind tunnel—we're in the process of taking down. We've got the full-scale wind tunnel at the Langley Research Center off of NASA's books. The Propulsion Systems Laboratory, at the Glenn Research Center, we took down within the last year. The altitude wind tunnel, we no longer needed; we got rid of that facility. So, we are aggressively looking at our infrastructure, because we have to become more efficient and cheaper to operate. Those things that we don't need we are and will get rid of.

Senator NELSON. Mr. Gerstenmaier, you're going to be assuming leadership for all of the human spaceflight efforts. What management or cultural changes do you feel are necessary to accelerate the goal of moving forward the goals of the NASA authorization law?

Mr. GERSTENMAIER. Again, I think we have two very talented directorates. You know, Doug's directorate, the Exploration Systems Mission Directorate, has done an amazing job of doing the new development activities and in leading those activities, doing the studies we described earlier. My directorate's been more focused on operations kind of activities—flying the Shuttle, flying Space Station, doing rocket propulsion tests, doing launch services, providing space communications, those kind of things.

I think my directorate has more of a kind of immediate focus, more of an operations focus of doing things. Doug has much more of the developmental focus. So, I think we can take the strengths of both of those directorates and put them together into a very effective organization. Because we want to make sure the things that we're developing are really going to be able to be operated in the most efficient manner in the future. Our folks understand how to operate those; Doug's folks know how to develop. We can take the best of both of those, from the two directorates, combine them into a strong directorate, with a sense of urgency, as called out in the authorization law, and we've discussed, to try to move forward to meet the time lines that we talk about.

We also know we are in a very budget-constrained environment. That will be tough for us to go manage. We need clear direction in the budget. We need to make sure we've got flexibility in our programs and flexibility in our development, so when the inevitable budget swings come, that will come, it doesn't totally upset the program. So, we'll build some, I call it, "agility," some ability to react to what we see from the outside, so we don't have a perfect plan that is optimized to just one set of constraints, that if we get a slightly different set of constraints, there's enough resilience,

enough agility in the system, we can continue move forward and ultimately deliver what you've asked for us to in the authorization law.

So, I think, in simple terms, what I'm going to try to do is take the strengths of both the directorates that are there, both of the strong cultures that are there, forward, blend those together into a new directorate that will meet the intent of what we've been asked to go deliver to this country.

Senator NELSON. What about the program offices for heavy-lift launch system, MPCV, and commercial crew development?

Mr. GERSTENMAIER. Doug's already taken steps, and you'll see that we've put the MPCV and the SLS and the 21st Century groups together. And the idea there is, we think there is enough commonality between all of those that they need to be worked together. And Dan Dumbacher, Doug has picked and I agree with, to lead that activity, from a headquarters perspective. And that's to make sure that we get an integrated look at those activities, that they're not done in isolation, that they're all moving forward, because they have to all occur in that same direction.

Doug also has a commercial organization, which we're going to get set up. We're trying to select someone for that position, to do the new commercial crew activity.

The commercial cargo activity, we've left that pretty much more at the center-director level. We haven't done much—we haven't really elevated that to the level at headquarters. I think that's appropriate for cargo. We can stay fairly lean in the cargo side, but the crew side, we clearly need some direction and some guidance from up here. They will do that.

And, as you're well aware, the Kennedy Space Center will be the Center that manages and oversees that commercial crew capability down in Florida. And we're looking to the folks down there to lead that activity with a deputy from JSC. And Doug has set all that up, and we'll leave that pretty much set the way it is right now.

Senator NELSON. Why don't you flesh that out? What's that going to mean to Kennedy for the Commercial Crew Program Office?

Mr. GERSTENMAIER. It'll be a Civil Service Project Office or Program Office set up at Kennedy Space Center to manage that activity. They will oversee the procurements associated with that activity. They're in the process right now—and Doug can elaborate—they're ready to do a Commercial Development II procurement activity. They will kind of oversee that activity. Or, excuse me, they're getting ready to award that now. That'll be there. They're, kind of, wrapping up the CCDev I activity—Commercial Crew Development I activity. And that office will do the day-to-day management of kind of overseeing that, with some guidance from headquarters, from kind of a top-level oversight and level-one requirements standpoint.

And Doug may want to add something.

Senator NELSON. Please.

Mr. COOKE. Right. The office has been a planning office, but has been doing all the work in setting up these procurements. They are working on the CCDev II procurement right now. That went out in October, with proposals back in December. And they're going

through the evaluation process right now. That's being led at KSC by Ed Mango's team.

That team will become the Program Office, when we're freed up to do that, which should be shortly. But, they're laying it out. That and finishing up that procurement exercise. They are laying out the steps for the follow-on procurements that would lead to commercial crew ultimate capability. They would be the oversight center for that development capability. They are getting support from JSC, in the areas of crew systems—and Brent Jett, from the Astronaut Office, is a deputy to Ed Mango—and they're providing the expertise that they need from JSC, but it is being led at Kennedy Space Center, and they are being very methodical and doing a great job of moving that forward.

Senator NELSON. Do you want to venture any numbers of the jobs in that office?

Mr. COOKE. I will have to take that for the record.

[The information requested follows:]

The current total number of Full Time Equivalents (FTE) for the Commercial Crew Program across all NASA Centers (not including NASA Headquarters) is 74. Of that number, 46 FTE are located at the NASA Kennedy Space Center. When fully staffed (anticipated for some time in FY 2012), the total number of FTE for the Commercial Crew Program is expected to be approximately 200, with the highest concentration of civil servants located at NASA Kennedy Space Center.

Mr. COOKE. I'm not sure what the current plan is. It's not a large office. But, they have a setup that they have laid out; it's been based on what they see they need, in terms of developing the requirements for these providers, as well as doing the oversight.

Senator NELSON. Dr. Weiler, with the loss of Glory, do you anticipate any changes in the Earth Science projects that are currently underway?

**STATEMENT OF DR. EDWARD J. WEILER, ASSOCIATE ADMINISTRATOR, SCIENCE MISSION DIRECTORATE, NASA**

Dr. WEILER. It was a great loss, Senator. We're trying to look forward to the next step.

Basically, there were two instruments on Glory. One was a total solar irradiance instrument. The purpose of that is to continue our decades-long study of the sun and how much radiation's actually coming to the Earth. That was going to be a new instrument on Glory. We've now lost that. There are two currently flying solar irradiance instruments. Regretfully, they're very old. One's 7 years old and I think one's 11 years old, on different satellites.

We do, however, have a backup instrument being built, for NOAA, called the TSIS, that's a Total Solar Irradiance Sensor. We've been in contact with NOAA. We are accelerating that development. We should have that ready to fly sometime in the 2012 timeframe. And we'll be working with NOAA to see what kind of satellite we might be able to put that on in the near term. We're hoping that the two instruments up there will continue the measurement of that in the near term.

The other instrument on Glory was a polarimeter. That was, for the first time, going to give us some very indepth information on the nature of pollution particles, so-called aerosols. We can get information like that by piecing together many other satellites, but

not so cohesively and excellently as we could have with the Glory instrument. We do not have a backup instrument for that ready, so what we have done, the Earth Science Division—is commissioned two 100-day studies to look at the feasibility of developing a new backup instrument, and also the scientific necessity for building a backup instrument, or whether we can wait for a new satellite that's even more sophisticated, I believe, which is planned, in the current budget environment, for about 2019 or so.

So, that's where we are right now. We'll have a lot more information—we'll be happy to share it—perhaps in about 2 or 3 months.

Senator NELSON. So, with regard to the first part of the instrument, as long as the two up there are going, you can keep that data coming. With regard to the second part of Glory, there's going to be a gap for how long?

Dr. WEILER. Well, again, this instrument was filling a gap, in the sense that there's a certain air bar we have on our climate models, because we don't really know the absolute size and nature of these aerosol particles. We can model them, and we can get a pretty good estimate of it, but it leaves a certain size air bar. Glory was going to reduce the size of that air bar.

So, it's not as if it was filling a gap that didn't exist—I mean, filling a data gap that didn't exist; it was making our air bar smaller. We'll continue to do the work we've been doing. And we'll either decide that it's so scientifically important that we'll delay other missions to try to replace this instrument quicker, or we'll wait for this newer instrument that's going to be launched in the timeframe of about 2019.

Senator NELSON. Is there any thought that you're going to rebuild Glory?

Dr. WEILER. Again, we can't really do what we did on OCO, because Glory was flying on a very old spacecraft that was originally developed for something, I think, called Vegetation Lidar Mission, about 10 years ago. So, we reused that spacecraft. It wouldn't make any sense to rebuild a spacecraft that's, basically, obsolete now. So, it's not as simple as OCO, where you could just—really, just take the diagrams and build a new one very rapidly. So, we'd have to evaluate what it would cost to go out to get a new spacecraft and build a new instrument, and cost that versus the value of doing that. And again, we'll know that in about 100 days.

Senator NELSON. The review of the James Webb highlighted deficiencies in management and budgeting practices at NASA, leading to the schedule delay and also the cost overruns. And that's not going to sit well around here, in this budgetary environment. So, why don't you, for the record, justify the importance of James Webb's telescope.

Dr. WEILER. That's actually easy, because I've spent most of my career on the Hubble Space Telescope—more than 30 years; I was a chief scientist for about 20 of those years.

Where we are on James Webb now reminds me of where we were on Hubble in the mid-1980s. A lot of people don't remember, because Hubble is such a great success now that it actually overran, 300 percent, and was delayed 7 years. When I joined the Hubble team in 1978, the launch was scheduled for 1983, at a cost of $400 million. It wound up getting launched in 1990, for a cost of $1.6

billion. But, we stuck with it, despite a lot of people who wanted to see it canceled. There were a lot of management problems, a lot of cost problems, there was a lot of blame all over the place. But, we stuck with it and we launched it. And, today, of course, Hubble, I would call the biggest scientific success in NASA history.

Senator NELSON. And no sooner had you launched it than you realized that it had deficient lens. And you had to go up and correct those.

Dr. WEILER. I was telling somebody, I remember sitting in this room, Senator, in 1990, defending—collaboration problem. I believe the chairman of this committee then was Senator Gore. So, I've had some experience in this room.

But, we did fix it. A lot of people didn't believe we could fix it. But, again, the NASA teams stuck together, at Johnson, Kennedy, Goddard, the contractors, et cetera, and we fixed it, utilizing the Space Shuttle mission in December 1993.

How is that relevant to James Webb? James Webb, for about the same cost in real—in constant dollars that Hubble cost in constant dollars, is going to be about 50 to 100 times more sensitive. James Webb will enable us to see the universe when the lights first came on, the first stars, the first galaxies, going all the way back to maybe 100/200 million years after the Big Bang. That's what we know James Webb will do.

As we learned from Hubble, I can sit here and expound on all the things we expect James Webb to do: It's going to look for extraterrestrial planets; it's going to study star formation, galaxy evolution. That's all very interesting and exciting. But, what was most exciting about Hubble were the things we didn't know, the questions we didn't know how even to ask. When we launched Hubble, there was no such thing as "dark energy." When we launched Hubble, there were no extrasolar planets.

The universe is a big place. And, even though we write textbooks about it, the universe out there doesn't always read our textbooks and sometimes surprises us. And I think James Webb is going to be that kind of mission for this country, if not for the world.

James Webb, as some people forget, is not just a U.S. mission. The Canadians are deeply involved, and a major partner is the Europeans, just as the Europeans worked on Hubble. It's an international mission.

The potential for James Webb to give us excitement to explore the universe, perhaps excite some of our school kids in middle school to perhaps do something unheard of—consider a career in science, engineering, or math—it's something I deeply feel. I was excited. I'm sitting here today, Senator, watching, as a young boy, John Glenn and Alan Shepard take off from the Kennedy Space Center. That inspired me to decide I wanted to be an astronomer, I wanted to go to Northwestern University, and I wanted to work for NASA—when I was 13 years old. I hope that things like James Webb, our Mars missions, can do that kind of thing to our 12- and 13-year-olds today, because this country needs scientists and engineers and mathematicians in the future.

I'm sorry for going on and on, but you asked me to expound.

Senator NELSON. Amen. How about the Alpha Magnetic Spectrometer?

Dr. WEILER. That's not a mission that's funded by my organization, so I'm really not too familiar with it. I believe the physics involved is a search for antimatter particles. It's a really exciting experiment. I hope it works, and I hope it finds some antimatter particles. But, we don't fund it, so it's not under my jurisdiction. It's really under Bill Gerstenmaier's jurisdiction.

Senator NELSON. Any comment?

And then I'm going to turn to you, Senator.

Any comment?

Mr. GERSTENMAIER. DOE is supporting most of the actual science on AMS. We're doing some of the integration activity, and launching it.

Senator NELSON. Senator.

Senator BOOZMAN. Thank you, Mr. Chairman.

Just real quickly, Mr. Melvin. The funding levels requested for education programs are less than those authorized for Fiscal Year 2012. And I think Congress would like to see increased educational activity at NASA. In Fiscal Year 2010, it's being stated that nearly 21,000 spacecraft-supported undergraduate and graduate students participated in authentics hands-on research. Do you believe/anticipate that we will be able to sustain that level of participation under the budget request?

**STATEMENT OF LELAND D. MELVIN,**
**ASSOCIATE ADMINISTRATOR, EDUCATION, NASA**

Mr. MELVIN. Senator Boozman, I think we're going to have to use our strategic partners to help us continue with the numbers of students that we reach at higher-ed and even in the middle schools.

We just came through a design team, where we had Norm Augustine and a number of other people looking at, What is NASA's contribution—or what should NASA's contribution be to helping motivate, inspire, and train students? And one of the things that they recommended we do was to help with middle school teachers, to basically help grow our seed-corn, so that we'll have more people in the colleges and being able to do higher-ed. That was one recommendation. Another recommendation was to ensure that we get new partners on board that can maybe take over some of the things that we're doing, supply the NASA content that we have, the rich resources of content, to better leverage the resources that we have, so we can then maybe increase the pool even bigger.

Senator BOOZMAN. Very good. And that's good.

I think that goes along with you, Dr. Weiler, in the sense, those things are so important: exposing young people.

Dr. Shin, can you briefly describe the NASA aeronautics research contributions to the aviation industry, such as the Boeing 787?

**STATEMENT OF DR. JAIWON SHIN,**
**ASSOCIATE ADMINISTRATOR, AERONAUTICS RESEARCH MISSION DIRECTORATE, NASA**

Dr. SHIN. Yes. Thank you, Senator.

Boeing 787, as you know, is going to be a very exciting airplane. According to Boeing's claim, it will have the lowest fuel consumption of any commercial airliners in the business. We have no reason to doubt that, because I—I have visited Boeing production line, as-

sembly line, and they have used, extensively, the composite materials on the fuselage and also wings. If you take a look at the wings, the shape of the wings, they look dramatically different from the conventional wings. And one of the reasons why they were able to do that is that the composite material has much stronger strength-to-weight ratio, so they can come up with a different design to support the structure and integrity.

NASA has been working on composite material research for decades—structures and materials. We believe a lot of that capability was successfully transferred to industry; certainly to Boeing, but not just Boeing, but to general industry.

Also, another notable technology there is what's called chevron nozzle, and it will reduce the engine noise substantially. So, current days, the environmental impact mitigation is becoming a really growing concern. A lot of airports even have curfews at nights, so that puts a 787 also at a higher advantage over, or a more competitive advantage to have quieter airplane. The chevron-nozzle concept was grown out of NASA technical community, and we collaborated with engine companies and airplane companies to deliver that technology.

Senator BOOZMAN. OK.

Thank you, Mr. Chairman.

Senator NELSON. Well, let's just follow up right there. With the aerospace industry being so important—2 percent of our GDP, half a million people employed, major U.S. export—you've got a pretty robust budget in this NASA authorization law as well as the President's proposal, for aeronautics. What are you doing to target R&D spending to make sure it's consistent with both the industry needs, as well as our national needs, for new technologies?

Dr. SHIN. Yes. Senator, before offering my response, if I may, I really appreciate, on behalf of NASA Aeronautics, for your strong support during the FAA reauthorization bill, by submitting an amendment to keep aeronautics within NASA. So, we very much appreciate that.

Senator NELSON. You didn't want aeronautics going over to all these other agencies, I take it.

Dr. SHIN. No.

[Laughter.]

Dr. SHIN. And so, we appreciate your support.

We are working heavily on NextGen and safety and environmental impact mitigation, as you know, Senator. I think the importance of NextGen is so critical, it is not just the air traffic management system capability, because you have to advance aircraft capabilities and also safety that will be in that national aerospace system. Also, Congress, almost 7 years ago, had the foresight to create a Joint Planning and Development Office to come together, departments and agencies, to work together on this very important initiative. For NASA, Aeronautics is investing almost 80 percent that will directly or indirectly contribute to NextGen. So, that's just one example of how we are helping, certainly FAA, to implement this very important revolutionary technologies and processes, and also industry.

And we just talk about 787. I think we are collaborating with industry, a wide spectrum of industry, to advance, again, safety tech-

nologies and new aircraft system, engine system capabilities, and certainly air traffic management capabilities to put our country, continue to be in the leadership position.

As you mentioned, Senator, I think the aviation industry is one of the few industry sectors that brings, still, a trade surplus. In 2008, the aviation industry brought almost $57 billion of trade surplus to the country. So, we've got to stay in the leadership position. And I think NASA Aeronautics is positioned to do that. And we thank you Congress for congressional continued support on that.

Senator NELSON. You developed winglet technologies, and that has helped save fuel cost. What other research are you doing to reduce fuel consumption?

Dr. SHIN. Yes. We are doing a development of a low $NO_X$ combustor, working with engine companies, and trying to have a substantially lower pollutant coming out of combustors. Also, it is important to make these combustors fuel flexible. So, with the emergence of alternative fuel and biofuels, we have to develop technologies for the combustor that will be working with whatever kind of fuel is coming online, next 20 or 30 years.

And also, we are developing completely new concept of airplanes that will be very different from conventional tube and wing configuration. Some of the system studies that we have conducted suggest that combining the smart operations and this new configuration with other state-of-the-art technologies, like a combustor, that I mentioned, potentially we could save as much as 40 percent of our fuel consumption, compared to the current state-of-the-art. So, that's the kind of target that we are working on.

Senator NELSON. Would you send us a list of those?

Dr. SHIN. Certainly will do that.

[The information requested follows:]

NASA's Aeronautics Research Mission Directorate is committed to research that promotes fuel efficiency and environmental compatibility while increasing or maintaining aircraft safety. Fuel currently represents the largest operating cost for U.S. airlines. Many of the aeronautics research activities currently being conducted by NASA have the potential, upon adoption, of reducing fuel consumption.

NASA systems analysis indicates that new operational procedures currently in development within the Airspace Systems Program (ASP) have the potential, if fully adopted into the National Airspace System, to reduce fuel burn by 400 million gallons per year during landing and takeoff phases of flight and an additional 200 million gallons per year during the en route cruise phase of flight. These savings correspond to about 3 percent of the annual fuel burned by U.S. commercial airlines. ASP is also developing improvements in ground operations that have the potential to reduce fuel burn during airport taxi operations by 15 million gallons per year, which would result in a reduction of 2 million pounds of $CO_2$ per year of harmful emissions in and around our largest airports. Some key areas of research within the ASP focus on developing new capabilities to:

- Demonstrate near term application of Automatic Dependent Surveillance-Broadcast (ADS–B) enabled technologies to enable fuel and time efficient arrivals (new FY11 initiative);
- Demonstrate near term application of ADS–B enabled technologies to enable efficient surface operations to reduce fuel, noise, and emissions (FY 2012 Presidents budget request);
- Demonstrate Efficient Descent Advisor (EDA) technologies with the FAA 3D–Path Arrival Management (3D–PAM) to enable continuous descent approaches in congested airports for reduced fuel consumption and reduced noise level during landing;
- Demonstrate non-stop taxi surface operations to reduce fuel-consumption due to current stop-and-go throttling operations;

- Optimize efficient arrivals, departures and surface operations through fuel-saving integrated arrival/departure/surface time management, route modification and adaptive speed control;
- Maximize national airspace efficiency with new processes to address demand/capacity imbalances from weather effects and system wide uncertainties to reduce travel time, distance, and delays which inherently reduce fuel consumption and emissions;
- Enable safe, time and fuel efficient, en route flight with varying weather while allowing for reduced distance between aircraft to increase air-traffic volumes; and,
- Reduce airborne and ground hold delays through enabling increases to system capacity by bringing to bear available resources and capacity to wherever demand is surging.

The Fundamental Aeronautics Program (FAP) and Integrated Systems Research Program (ISRP) conduct complementary research aimed at reducing the fuel burn of aircraft. New concepts and technologies undergo early-stage development within FAP. Individual technologies which have matured are then evaluated at an aircraft system level in relevant environments (including flight test) within ISRP. Within these Programs, research is being conducted on technologies that will improve fuel efficiency for a variety of aircraft and have a direct effect on overall fuel consumption for the aircraft industry. Specific areas of research include:

- New aircraft designs and configurations, including rotorcraft and subsonic vehicles, that are more efficient;
- Lightweight structural components, such as airframes, to reduce subsonic aircraft operating empty weight;
- Advanced fuel-efficient engine designs;
- Ways to reduce subsonic aircraft drag, with minimal impact on operating empty weight, for total aircraft energy reduction; and,
- Some advanced structural and propulsion-related material research intended primarily for supersonic aircraft applications will also benefit subsonic aircraft by helping to reduce vehicle and propulsion system weight thereby reducing fuel consumption.

Senator NELSON. OK.

Mr. Melvin, how are you going about evaluating NASA's education programs? And then, once you get those evaluated, how do you go about figuring out how you use that data to improve the quality of the education initiatives?

Mr. MELVIN. Thank you, Senator. That's one of the biggest areas that we're going to work on with this new redesign of education. The evaluation and accountability part of our budget will be trying to get more people involved in that area. That's one of the biggest concerns that we're having: How do you know that dollars we're spending on the programs are actually giving you the results that you desire?

And so, one of the things that we're looking at doing is also, like I said before, partnering with other agencies. The America's COMPETES Act has us working with NSF and other agencies to see what the Federal Government's national portfolio is in education. And that way we can maybe contribute a piece, NSF can contribute a piece, and Department of Education can contribute a piece. So, we're going to be utilizing people from NSF to help us with evaluation practices to get better evaluation systems for our programs.

Senator NELSON. How about the Summer of Innovation that was a pilot in 2010? Can you describe some of the accomplishments of that pilot project?

Mr. MELVIN. Senator, we reached about 155,000 students and teachers. Many of the projects that we did, some of them were with

kids helping build wind tunnels. Some Native American students were actually making food pods. We had middle school students actually helping program spheres, through the Massachusetts Space Grant, where these spheres are actually up on the Space Station, so they could have a hands-on experiential activity that's actually being inspired by space. So, those are some of the things that we did in 2010.

We reached about 22,000 students that actually had 30 hours of hands-on instruction, with at least 7 hours of NASA content. Now, that amount of content is not enough to give us an indication on if a kid's going to go from a "D" to a "B," but we need to continue on with the follow-on activities to ensure that we can start to look at working with school districts trying to track the students, to see how their performance gets better. So, that pilot did give us some indications that 30 hours is a good number of hours for instruction. But, we're going to have to continue with some follow-on project progress to definitely see how these students change their grades.

Senator NELSON. Do you intend to continue the program?

Mr. MELVIN. Yes, sir. This year, I think 36 proposals have come in. We're in the review process right now. We are going to use the resources that we have in the continuing resolution, use those resources to fund the programs that we're going to have this summer, where we actually work with middle school teachers and then they, in turn, use the NASA content to instruct middle school students.

Senator NELSON. What does NASA do with a whole bunch of different partners, private and public, in order to increase STEM education?

Mr. MELVIN. Well, we've been working with a number of partners. One example is, we just signed up a new partnership with LEGO. Every child in the world knows about LEGO. LEGO is all around the world. The LEGO Foundation actually gives out free LEGOs to schools, as well as the curriculum associated with it. So, on STS–134, we're sending up LEGOs to space. That way, we can have some design challenges with astronauts and with students on the ground, to get them as inspired as we can, using the resources that we have as a national laboratory on the ISS, also using our assets, as astronauts, to help them call into schools, doing downlinks, those kinds of things.

We partnered with Donovan McNabb, from the Redskins, to get kids to think about the physics of football. So, we were in his training camp, this past summer, where we had about 400 kids thinking about how physics can help them with their football playing.

Also partnering with musicians, Mary J. Blige and MosDef and Donna Karen, we've done work with them to let kids start to think of alternative careers besides just sports and entertainment. So, use the icons that the kids gravitate toward to let them help tell the NASA message, use the NASA content.

We had a case this past summer, during Summer of Innovation, where we had the Foundation for Advancing Women Now, Mary J. Blige's foundation—her girls were actually teaching NASA content to the Harlem Children Zone students of Geoffrey, Canada, and Harlem, New York. So, this is a way that the actual students can then reach back and help excite and motivate and inspire, using our NASA content.

Senator NELSON. And how are you using the International Space Station to interact with your educational programs?

Mr. MELVIN. Well, as I said, on the Massachusetts Space Grant, they have this little sphere. They're like little remotely operated spheres that float around the Space Station. The students can actually uplink and program them to have competitions from the ground. So, that's one way. Also, using our astronauts to actually call in to classrooms, to actually motivate and inspire kids.

Actually, when I was in space in 2009, we called into Tennessee, to Senator Gordon's district, talked to about 300 or 400 kids to get them inspired and motivated. So, however we can use the resources on the SEEDs Program, and there are many different types of programs that we've used to help motivate and inspire.

Senator NELSON. Dr. Weiler, you are facing a shortfall in supply of plutonium 238. At the funding levels that you're looking at, how long is it going to take before the U.S. has a production capability for PU–238?

Dr. WEILER. Thank you for asking that question, Senator.

We started working with the Department of Energy in fiscal 2010. In fiscal 2010, we worked out a agreement, at my level and at the DOE equivalent of my level, with OSTP and OMB, that we could restart plutonium production at about the 1- to 2-kilograms-per-year level, which would meet our needs at NASA. We submitted that to the Congress but, the DOE-side of the appropriations process did not support it. So, we've resubmitted it again in 2012 in the President's budget, and we await the appropriations process once again.

In the meantime, because of the CR situation, if we are held at the Fiscal Year 2010 level in the Science Mission Directorate, that's about a 20-percent reduction from the President's Fiscal Year 2011 request. At that kind of reduction, we will not be able to put our 15 million in. So, we hope that we can resolve this by the beginning of Fiscal Year 2012. We are ready to start funding it, but, we do need the DOE's contribution of the equal $15-million amount. That would get us enough plutonium if we were to do a outer-planets large mission in the 2020 timeframe, that would be sufficient to meet the needs of that mission.

Senator NELSON. Where does your plutonium come from now?

Dr. WEILER. It would be coming from Oak Ridge. What we did discover, in the process of working together, was that we would not—at the beginning of this process, Senator, back in Fiscal Year 10, it was looking like DOE wanted to build a brand new facility, and this would have cost an enormous amount of money. But, once we really honed in on what the real requirements were for NASA, how much plutonium we really needed, it turned out to be only 1 or 2 kilograms per year. DOE and Oak Ridge, combined, figured out that they could meet that with existing facilities. And that's why the cost has been reduced to only $30 million a year, roughly; 15 million from each agency.

Senator NELSON. For the record—why don't you describe, for the record, if you don't have a supply of plutonium 238, what's going to suffer?

Dr. WEILER. Ultimately, our existing stocks will run out. I can't give you the exact number. We'll take that one for the record, as to when the stocks would run out.

[The information requested follows:]

The number of missions that can be supported with current Pu-238 inventories depends on the power required by proposed missions and the planned power sources. Based on NASA's last formally updated projected mission power needs and the Department of Energy's estimates in meeting NASA's fueled power systems, current inventories can support missions through the 2020 timeframe, including a Discovery-class mission using up to two Advanced Stirling Radioisotope Generator (ASRG) power sources.

NASA is in the process of reevaluating its mission planning set in light of the recent update to the decadal survey "Visions and Voyages for Planetary Science in the Decade 2013-2022." Regardless of the specific mission planning set, which does evolve over time, Pu-238 has been used on a consistent basis and radioisotope power systems remain vital for meaningful exploration of the majority of the solar system, including significant portions of the Moon and Mars. We continue to exhaust a limited supply, so the speedy restart of domestic production ofplutonium-238 is important to maintaining U.S. leadership in planetary science.

Dr. WEILER. But, it would preclude our ability ever to do a large-scale outer-planets mission, for instance, like a mission to the Moon Europa that circles Jupiter, ice-covered moon, where we're very certain that it has an ocean underneath it. Of course, wherever there's water energy, you have to ask the question, Is there possibilities for life? It would certainly preclude a major mission to another moon, Titan, which the Cassini Mission has shown us is extremely interesting, around Saturn. We've discovered liquid methane lakes, methane rain on this moon. It has a thick atmosphere. The science community considers it a very high priority for the next decade, perhaps, the decade after this one.

These kinds of missions would not be possible, because, once you get out to Jupiter, you're dealing with about 4 percent the solar radiation that we get here. At Saturn, it's probably down to 1 percent or less. You just cannot use solar panels that far out. So, it would stop our many-decades-long exploration of the outer solar system.

Senator NELSON. Tell me, any one of you six, given the turmoil that NASA's been going through, have you seen any diminution of the best and the brightest, when they come out of college, that have always wanted to go to work for NASA?

Dr. WHITLOW. One of the programs we have to replenish our pipeline and make sure we have the workforce of the future is our Student Career Exploration Program that's at various centers. In any one year, there are about 500 to 600 students in that program, in addition we have other programs that we use to help replenish our pipeline. In the SCEP Program—that's Student Career Exploration Program—most of those students end up with NASA employment. We find that, when we advertise for jobs at all levels, we get many, many applicants for our jobs. So, there is very high interest in career opportunities at NASA.

Once we hire people on, we have very aggressive programs to retain our workforce with onboard process. We provide mentors, we provide coaches, we provide rewards programs, training, development. And so, not only is there great interest among the community, in coming to work for NASA, but, once we hire people on board, they tend to stay for quite a while.

Senator NELSON. Anybody else?

Mr. MELVIN. Senator, I think that a lot of the students that come to NASA, they just have this fascination with space. And it's something that I think one of the only agencies in the Nation and the world, really, that has the ability to attract people to come work at an agency like ours. And so, we do get the best and the brightest. We get a cross-section of different types of students, but everyone comes and works hard and is really dedicated to the mission of human exploration and all of our missions at NASA. So, I think it's a combination of students.

But, I think, if we can help get more students to know exactly what we do at NASA, maybe get a better way to get that message out using more of these strategic partners, using other assets using your offices also to help spread the word, as to the things that we do in our mission, I think we'd get even more students inspired and motivated.

Thank you.

Senator NELSON. Mr. Gerstenmaier, as you know, in the 2010 authorization law, it provides a series of steps that must be taken as you go through the human part of the commercial delivery of humans to the ISS. Can you provide us with a status report on the compliance with these requirements?

Mr. COOKE. I'll take a question for the record, to get you the exact details.

[The information requested follows:]

P.L. 111–267 outlines specific steps that NASA must take related to commercial crew development. These steps include: (1) human rating requirements; (2) commercial market assessment; (3) procurement system review; (4) use of government-supplied capabilities and infrastructure; (5) flight demonstration and readiness requirements; and, (6) commercial crew rescue capabilities.

NASA plans to satisfy all the requirements in the P.L. 111–267. The current status of these efforts is as follows:

- Item 1, human rating requirements were provided to Congress in December 20 10 via the "Commercial Crew Transportation System Requirements for NASA LEO Missions" document;
- Item 2, commercial market assessment was delivered to congress on in April 2011 via the "Commercial Market Assessment for Crew and Cargo Systems" report.
- Item 3, procurement systems review; NASA is currently developing the commercial crew transportation acquisition and procurement strategies. Once these strategies are finalized, NASA will provide Congress a description of the proposed process and justification of the proposed process.
- Item 4, use of government-supplied capabilities and infrastructure; NASA is currently assessing future infrastructure and capabilities required to support future programs.
- Item 5, flight demonstration and readiness; NASA is developing a human rating process and minimum set performance objectives to be achieved be commercial crew transportation partners. NASA will certify commercial crew transportation providers prior to allowing NASA or NASA sponsored astronauts to fly on any commercial crew transportation system.
- Item 6, commercial crew rescue capabilities; NASA is including crew rescue into the set of commercial crew transportation human rating requirements. NASA will certify commercial crew transportation providers prior to allowing NASA or NASA sponsored astronauts to fly on any commercial crew transportation system.

Mr. COOKE. But, I know that our office at KSC is—has those requirements in front of them, and that they intend to comply with those. But, I can help with a status.

Senator NELSON. I thought you were retiring.

[Laughter.]

Senator NELSON. I thought all of your stuff was going to Gerstenmaier.

Mr. COOKE. We're working closely together.

Senator NELSON. All right. Well, can you also give us the full market analysis for the commercial crew capabilities?

Mr. COOKE. That is currently in review at NASA.

Senator NELSON. And——

Mr. COOKE. So, that is work that is being reviewed by our offices now.

Senator NELSON. When are we going to get that?

Mr. COOKE. I don't remember the exact date it's due, but I think it's just a couple weeks in the downstream, that—the plan is. I'll have to go back and look at the exact timing. I believe that was a 180-day report. But, we're—we do have that in review currently.

Senator NELSON. I happen to be someone that thinks that we can develop the commercial crew capability, and that we can do it rather expeditiously. And—in parallel, that we can develop the heavy-lift rocket—and this is why I keep saying, let's talk about what we can do, not what we can't do—that if you take the law, which is an evolvable system, that we can do that, and we can do it in parallel, while we're developing the commercial and cargo crew capability to go to the Space Station. But, we need these reports.

Now, speaking of the report, getting back to the 90-day plan, an incomplete 90-day plan—we're losing time—I want to know if you, Mr. Cooke, will commit to bringing us the information as it is available, and not waiting around so that we're not getting it. We don't need a final report.

What we're trying to do is keep action going, here. Will you commit to that?

Mr. COOKE. We are certainly with you on keeping the action going. And we have significant steps that we're taking in the next weeks. And we will be happy to report back as we develop that information, in the interim.

Senator NELSON. Do you have the authority in order to commit that you will bring that information to this committee as it becomes available?

Mr. COOKE. I will certainly do my part. I have to work through our system. But, certainly, I'll do my part to get information available to you.

Senator NELSON. Does that kind of information—before it comes to the Committee, does that have to go to OMB?

Mr. COOKE. Generally, there is a review that includes the OMB and OSTP.

Senator NELSON. Well, that's where a lot of the hangup in the past have been. It gets stuck over in OMB. How about OSTP? Do you get a fairly quick review there?

Mr. COOKE. We work closely with them, all of them, and we will get this data to you as quickly as we possibly can.

Senator NELSON. Sure, you work closely with them, but that's not the question.

[Laughter.]

Mr. COOKE. Well, my intent is to get you data as early as possible. I can tell you that.

Senator NELSON. Well, you know, if we're going to save the NASA budget, in a time when—you saw what happened in the House and what happened in H.R. 1, which this Senator voted against last week, and it didn't get a lot of votes in the Senate. But, you can imagine what would happen if other people had their way. You can imagine what would happen to our space program. So, as we're trying to protect our space program and the future of NASA, we've got to have data. And we can't keep having these delays like we've had on these reports.

Now, you have the luxury of retiring, so why don't you just go full bore and bust down some doors, since, when you step on toes, it's not going to make any difference.

[Laughter.]

Mr. COOKE. Well, I promise you I'll go full bore. And I am committed to staying with this through these steps to get these on track. And I certainly will do everything I can to get you information, you and your staff.

Senator NELSON. You didn't say whether or not you would step on some toes.

Mr. COOKE. I don't think I've hesitated in the past.

[Laughter.]

Senator NELSON. Well, keep after it.

All right. Well, thank you all for a very comprehensive hearing. I think we accomplished what we wanted to. We wanted to get you all to lay out what's going on. And this is a tough time.

I want to note that the record is going to stay open for a week for members of this committee to submit further questions for the record.

And the meeting is adjourned.

[Whereupon, at 4:50 p.m., the hearing was adjourned.]

# A P P E N D I X

PREPARED STATEMENT OF HON. JOHN D. ROCKEFELLER IV,
U.S. SENATOR FROM WEST VIRGINIA

I would like to welcome all of our witnesses here this afternoon to discuss NASA's progress and challenges in implementing the *NASA Authorization Act of 2010*. No conversation on implementation, however, would be complete without also discussing the destructive impact that sporadic funding is having on NASA's mission and priorities.

NASA continues to be an agency in transition. After 30 years and 135 flights, the Space Shuttle program is retiring. Just last week, we watched Discovery's last mission. There is a great anticipation about what's next for NASA after the shuttle program comes to a close.

NASA's shuttle program has led to major scientific successes and discoveries. It's launched and repaired the Hubble Space Telescope, sent up the world's most powerful X-ray telescope, opening a window to the universe, and completed construction of the International Space Station. The Space Station is of particular interest to me—not necessarily because of what it teaches us about space—but because of the discoveries it's made that could improve the lives of every American. The shuttle also helped capture the imagination of a new generation of people too young to remember previous missions.

The space station itself recently passed a milestone of its own. Last November marked 10 years of a continuous human presence on the space station. Much of that time has been devoted to construction, but the astronauts on board still found time to conduct more than 1,200 experiments that supported the research of more than 1,600 scientists worldwide.

One very significant discovery is that some bacteria—such as Salmonella and Methicillin-resistant Staphylococcus aureus (MRSA)—become more aggressive in causing disease in the station's microgravity environment. I think everyone here is familiar with the enormous public health risk posed by antibiotic resistant bacteria. Any progress we can make on this front will pay dividends for years to come. This discovery is helping scientists develop potential vaccines for both of these infections and, if successful, would save thousands of lives each year. For these reasons and for the scientific promise of future exploration, we need to get NASA's transition right.

Exploration, however, can take many forms and there is one area of the President's FY 2012 budget request for NASA that particularly concerns me. That's the funding requested for NASA's education programs. The FY 2012 request is $138 million, which is nearly $42 million less than what was enacted for FY 2010. Teaching our students science, technology, engineering and math (STEM) has never been more important to innovating and competing in this global economy. In recent visits to schools in my own state of West Virginia, I have seen first-hand the success these programs have in inspiring our next generation of scientists and engineers. NASA's Space Grant Program, for example, can be found in each and every state across the country. In my own state, the program funds fellowships and scholarships for students pursuing STEM careers at West Virginia University, Marshall University, and other colleges and universities around the state.

NASA's EPSCoR—or Experimental Program to Stimulate Competitive Research—is another education program working to improve STEM research and development in the aerospace field. In West Virginia alone over the past 5 years, this competitive program has supported hundreds of students and faculty in their research, resulted in millions of dollars in new funding, supported more than 100 scientific papers, and led to new patents. This type of program allows every state to fully participate in the research activities that lead to new discoveries, create new jobs and educate our workforce.

I would again like to thank our witnesses for being here today. I look forward to their testimony.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN D. ROCKEFELLER IV TO NASA ASSOCIATE ADMINISTRATORS

**Commercial Spacecraft/Independent Verification and Validation**

The President's FY 2012 budget request again prioritizes the development of commercial spacecraft for American access to space. In addition to providing U.S. human access to space, commercial spacecraft will be interacting with important and irreplaceable national assets such as the International Space Station and NASA astronauts.

*Question 1.* What actions are being taken to maintain high levels of safety, reliability and availability standards for commercial spacecraft to prevent against catastrophic errors that can and do occur in software development?

Answer. Providers of commercial cargo services for the International Space Station (ISS) must face the challenges of mastering automated rendezvous, proximity operations, and docking with a crewed spacecraft. While these tasks have been demonstrated many times by the Russian Progress vehicle, and twice each by the European ATV and Japanese HTV, the technologies and techniques required for their achievement are difficult, but clearly not impossible, to develop. All commercial cargo vehicles intended to dock or berth to the ISS must meet the same visiting vehicle standards for each of their ISS missions. These requirements are laid out in the ISS Commercial Orbital Transportation Services (COTS) Interface Requirements Document. These standards include requirements for automated rendezvous and joint proximity operations, physical and software interfaces, and overall safety. These requirements are consistent with those provided for the ATV and HTV. NASA has been working closely with the commercial partners through the demonstration phase and will continue to work with them through the CRS missions to ensure that these requirements have been verified for each mission.

NASA is responsible for providing both rescue services and transportation to and from the ISS for U.S., Canadian, European and Japanese astronauts. Prior to carrying ISS astronauts, industry providers must meet the ISS interface requirements outlined above as well as stringent launch vehicle and spacecraft design, operations and safety requirements. The Commercial Crew Program's 1100 suite of documents is based upon NASA Human Rating and Safety Requirements, and incorporates launch vehicle, spacecraft and crew systems requirements as well as specifications and standards against which commercial crew transportation providers will be verified and certified. NASA is continuing to work to mature these requirements in an effort to ensure the U.S. is fielding safe systems for future ISS crew transportation needs. In addition, all commercial crew systems will have to meet the same safety requirements as other NASA human spaceflight systems.

For COTS and Commercial Resupply Services (CRS) missions, NASA, SpaceX, and Orbital Sciences are taking steps to protect against catastrophic errors that can and do occur in software development. Both partners have implemented stringent software development and testing processes and have engaged external independent verification and validation expertise to ensure software systems function as expected. Extensive joint software testing is scheduled with each partner and the ISS program. In addition, each partner is performing hardware in the loop testing to check the functionality of the software with redundant strings of computer and avionics equipment that they use in the flight vehicles.

*Question 2.* Is NASA prepared to stipulate the use of the NASA IV&V Center when issuing Space Act Agreements with commercial entities in support of commercial crew and cargo program contracts?

Answer. By their nature, Space Act Agreements do not allow the imposition of requirements; therefore NASA cannot stipulate the use of the NASA IV&V Program.

For cargo-only missions, Space Act Agreements were utilized for capability development as well as the upcoming on-orbit demonstration phase. For the on-orbit demonstration phase, the commercial companies proposed demonstrating delivery of cargo to the ISS. NASA accepted their proposals, but as part of that acceptance to "berth" with the ISS and deliver cargo, NASA imposed the condition to meet International Space Station (ISS) Visiting Vehicle Requirements.

The ISS Visiting Vehicle Requirements require software product assurance from an independent party with a clearly defined separate reporting path from the development organization but do not specifically require companies to use NASA's IV&V Program. Space Act Agreement participants may procure NASA IV&V services from NASA's IV&V Program.

For the Commercial Cargo Resupply Services contract phase, NASA elected to impose the same software assurance requirements as used for the Cargo Demonstration phase, *i.e.,* imposing the ISS Visiting Vehicle Requirements which require software product assurance from an independent party with a clearly defined separate

reporting path from the development organization. Again, the participants may choose to procure IV&V services from NASA's IV&V Program.

For commercial crew missions, NASA is deliberating the application and scope of software assurance and IV&V requirements. Currently, commercial crew is just starting the second round of short duration Space Act Agreements aimed at early capability development. The same rules of engagement for Space Act Agreements apply to this early phase of commercial crew capability development as were applied to the cargo-only capability development via Space Act Agreements (see above). When NASA gets to the point of contracting for development work, and imposing technical requirements on the contractor, the appropriate level of IV&V services will be considered.

**NASA Independent Verification and Validation Center**

The President's FY 2012 budget request proposes a level of $32 million for the IV&V Center, a severe and disproportionate cut of $13 million below the FY 2011 President's budget request of $45 million and $8 million less than the FY 2010 enacted level of $40 million.

*Question 3.* What human safety-critical and mission critical software projects will receive Cross Agency Support-funded IV&V in FY 2012 based on the FY 2012 request?

Answer. Based upon the FY 2012 request NASA conducted a risk-based assessment and identified that IV&V for the following projects will be funded from Cross Agency Support:

Human Safety Critical Software

- ISS (International Space Station)
- Commercial Crew Program—partial support*

Safety and Mission Critical Software

- MSL (Mars Science Laboratory)
- JUNO
- MMS (Magnetosphere MultiScale)
- SMAP (Soil Moisture Active and Passive)
- GPM (Global Precipitation Measurement)
- JWST (James Webb Space Telescope)
- GRAIL (Gravity Recovery and Interior Laboratory)
- MAVEN (Mars Atmosphere and Volatiles Environment)
- AFSS (Autonomous Flight Safety System)—Independent Assessment only

*Question 4.* What risks will NASA now be accepting by either not performing or outsourcing IV&V activities on lower priority missions?

Answer. NASA does not intend to waive or outsource IV&V services for human safety critical software. By not performing IV&V on lower priority mission critical software, NASA will be accepting the potential risk that; (1) the software developer's verification and validation activities are not adequate to ensure the correctness, quality and reliability of the mission's software; and (2) that NASA software assurance activities are not sufficiently effective at identifying those inadequacies. Not performing IV&V on mission critical software reduces the potential to find software errors that could contribute to loss of mission, loss or damage of NASA assets, or cost and schedule overruns.

By outsourcing IV&V, NASA will be accepting the risk that the IV&V activities performed by other IV&V agents may not be equivalent to the rigorous systems engineering processes employed by the NASA IV&V Program.

*Question 5.* Does this budget allow NASA to ensure mission success for basic research, development, and newly proposed programs, such as robotics?

Answer. The proposed IV&V budget will not allow for the additional assurance IV&V brings to mission success for these types of projects; however, NASA will continue to ensure mission success since the fundamental software requirements, controls, and assurance activities that are applied to NASA programs to ensure safety and mission success will remain in place. Typically, IV&V is not applied to basic research and lower technology readiness level projects. However, if a robotics mis-

* Based upon recent NASA decisions, the IV&V Program and the HQ Office of Safety and Mission Assurance are seeking funds from the Human Exploration and Operations Mission Directorate to fund IV&V for the Multi Purpose Crew Vehicle (MPCV) program, the Space Launch System (SLS) program, the Command, Control and Communications Element (CCCE) project, and supplemental funding for the Commercial Crew (CCP) program.

sion is selected for NASA IV&V based upon a risk-based assessment, the IV&V may be funded from Cross Agency Support.

*Question 6.* What is the impact of the FY 2012 budget request on employment levels at the IV&V without additional internal NASA or outside reimbursements for services?

Answer. The FY 2012 request will reduce funding available to contractors equivalent to approximately 40 full-time technical contractor personnel.

*Question 7.* Is it realistic to assume that project managers will pay for internal IV&V out of project budgets if their projects are subject to budget cuts?

Answer. NASA applies IV&V services based upon an assessment of risk. Given that the Mission Directors are accountable for the safety and mission success of their programs, it is realistic for the Chief, Safety and Mission Assurance and the Associate Administrators of the NASA Mission Directorates to examine individual projects and the risks the projects face, and to determine if additional funding from programmatic sources should be applied for IV&V services.

*Question 8.* Are there incentives NASA could offer for project managers to use internal IV&V rather than external sources?

Answer. Other than the obvious incentive of Agency level funding, there are many advantages of using the NASA IV&V Program over external IV&V vendors. The following are some examples of those advantages:

- NASA domain knowledge (17 years of experience)
- Heritage information (access to technical information on past projects, including over 15,000 historical issues)
- Procurement of services is easy and efficient (NASA to NASA)
- Shared IV&V tools and methodologies

*Question 9.* Please describe the steps that NASA is taking to assist the IV&V Center's diversification of its customer base within NASA, and with other federal, state, and local government entities.

Answer. NASA management has encouraged collaboration with other government entities and has encouraged the NASA IV&V Program to pursue diverse customers. Additional IV&V work with other Federal, state and local government entities will enhance the IV&V Program's knowledge and experience base and will help ensure core competencies within the workforce are maintained. NASA provides limited funds for travel to potential customers' sites for information exchange and for staff to support site visits by potential customers. NASA sends IV&V Program staff to government and industry exchanges, which allow the IV&V Program personnel to meet with potential customers, understand their challenges, and communicate the benefits of the NASA IV&V program.

**NASA Classroom of the Future**

*Question 10.* Please describe NASA's plans for continued work with the Classroom of the Future (COTF) beyond March 2012.

Answer. The NASA-sponsored COTF is an activity associated with the NASA LEARN Project (Learning Environments and Research Network). Managed by the Center of Educational Technologies at Wheeling Jesuit University in Wheeling, West Virginia, COTF recently began a one-year extension to a 3-year Cooperative Agreement that ended on March 2, 2011. The current extension ends on March 2, 2012. During this period, COTF will continue its operation of the DLiNfo Webcast Channel on the NASA Portal (*dln.nasa.gov*). It will also continue development and management of the *NASAtalk.com* online suite of collaborative tools for internal and external educators. COTF will finalize data acquisition, analysis, and findings leading to a formal presentation to NASA in the area of Learning In Virtual Worlds. The report will summarize development, implementation, and related research of MoonWorld, a Lunar geology-oriented online, learning experience. Additionally, COTF will explore various aspects of creating courses for and delivered through mobile devices.

Various factors will determine the continuance of COTF's activities after the conclusion of the current Cooperative Agreement. The Agency is currently developing strategies for responding to the recommendations from the NASA Education Design Team Review. An effort is also underway to revise the NASA eEducation Roadmap that was developed several years ago. The roadmap focused heavily on gaming and virtual worlds and will most likely be updated to include significant attention to the use of mobile devices in education. COTF's existing research in learning in virtual worlds and its new initiative in creating educational applications for mobile devices will strengthen the potential for another and final extension period beyond March, 2012. In the event that a new solicitation is offered during the coming year, COTF

will most certainly be a worthy candidate for consideration. Coupled with COTF's successes with management of the DLiNfo Channel and the recognized maturity of its *NASAtalk.com* website, continuance of its partnership with NASA in some form is a strong possibility.

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RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO DOUGLAS R. COOKE

*Question 1.* Since the enactment of the NASA Reauthorization Act of 2010, signed into law as P.L. 111–267 by President Obama on October 11, 2010, please summarize your current plans for (a) design, (b) development, (c) procurement strategy, (d) schedule, and (e) contract modifications with regard to the Space Launch System (SLS) and Orion/Multi-Purpose Crew Vehicle (MPCV). Include in your response actions taken which were not reported in the "Preliminary" report to the Congress submitted on January 11, 2011, in partial—that is to say, incomplete—response to the reporting requirement of Section 309 of P.L. 111–267.

Answer. NASA is providing semi-monthly briefings to Committee staff regarding the status of SLS and MPCV, and we will continue to do so. In addition, we are providing details about our preliminary planning process to the Committee as quickly as possible, per the terms of the May 18, 2011, letter from the Senate Commerce Science and Transportation Committee.

With regard to progress made on the MPCV, please see the attached white paper which denotes that we have determined that the Lockheed Martin Orion contract will be used for at least the development phase of the MPCV. Further details about the MPCV and the SLS planning process will be provided in a follow-on report to Congress in the summer timeframe.

*Question 2.* What actions have you taken and what and forward progress have you made in firming up the design, initiating development and actual contracted work for building SLS and MPCV/Orion since enactment of the NASA Reauthorization Act of 2010?

Answer. Since the interim report, the SLS formulation phase continued with multiple parallel activities to help drive down the development and operations costs for the SLS. NASA has continued to identify relevant work from the Space Shuttle Program and Ares Project that will be transferred to the new SLS Program, while also continuing to define the requirements for the new SLS system.

NASA's Marshall Space Flight Center has completed its internal Requirements Analysis Cycle (RAC) studies in parallel with 13 complementary studies being conducted by private industry under BAA study contracts. The BAA was a competitive solicitation, utilizing approximately $7.5 million in FY 2010 dollars to conduct six-month studies examining the trade space of potential heavy-lift launch and space transfer vehicle concepts. The BAA study contracts focused on achieving affordability, operability, reliability and commonality at the system and subsystem levels with multiple users, including other Government, commercial, science and international partners. These trade studies also provided a "fresh look" at innovative launch vehicle concepts, propulsion technologies and processes that can be infused into the development of the new human exploration missions—information that was used to help inform the overall selection and development of the final SLS vehicle detailed design. The BAA study contractor delivered their final briefing to NASA on April 28, 2011. Data obtained through the interim and final out-briefs helped NASA determine the feasibility of meeting top-level mission requirements with notional launch vehicle architectures, while defining affordability strategies, streamlining systems engineering approaches, and identifying best practices that will be applied to the final concept selected to go forward into formal design and development. In addition, some BAA respondents proposed approaches with prices below historical averages and NAFCOM calculations. The RAC teams delivered their final results the week of February 14, 2011. The RAC activity consisted of a NASA multi-Center formulation activity that studied various launch vehicle configurations, including the NASA Reference Vehicle Design (RVD) to develop and refine the vehicle design concepts and to determine whether the NASA Reference Vehicle Design meets the SLS mission requirements as well as the Administrator's goals that the design be affordable, sustainable, and realistic. On March 10 and 11, the SLS Program conducted its Mission Concept Review (MCR) which is an initial engineering milestone in the program's formulation lifecycle that evaluated proposed SLS concepts in relation to NASA's needs and objectives, and determined the program's readiness to begin Phase A (Formulation). During MCR, the SLS team presented the various RAC launch vehicle concepts against cost, schedule, and performance requirements. This process included describing concepts of operations and risk reduction plans. A

day of detailed technical briefings was followed by a day of deliberation by an independent review team, which culminated in agreement that the SLS Program was ready to brief NASA Headquarters on its readiness to proceed into Formulation, with multiple concepts being brought forward for further study.

On June 15, 2011, NASA made a key technical decision about the design of this new Space Launch System and will be releasing details about that decision soon. The approach considered the ability to accommodate a variety of missions, design flexibility, minimizing development risk, workforce considerations, and industrial base concerns. This vehicle design is consistent with the basic requirements outlined in the law, and will be evolvable to lift at least 130 metric tons in its final configuration. It will maximize the use of heritage hardware and experience, using a LOX-hydrogen core and upper stage. In early stages of the program, the design will use solid rocket boosters, but will consider a competitive procurement of booster capabilities for the final vehicle design. NASA developed this design after thorough analyses of risk, schedule, and performance. ,.. As a key element of the development plan for the integrated system, NASA has included, in partnership with industry, innovative approaches to developing and operating this system in a sustainable, efficient way. Though this was a thoroughly analyzed and critical step, it was not a final decision for the Administration.

Currently, NASA has procurement teams who are mapping SLS requirements (those outlined in the NASA Authorization Act of 2010 and those we are currently developing) against the Ares contracts to determine if the new requirements fit the scope of the existing contracts. For the SLS, NASA is reviewing each element of Ares (First Stage, Upper Stage, Upper Stage J–2X engine and avionics) to determine whether the new SLS requirements are within scope of the current contract. However, final acquisition plans for the SLS is not expected until the summer/early fall timeframe, and will be provided to Congress as soon as it is available.

Regarding the MPCV, in accordance with the NASA Authorization Act of 2010, the FY 2011 Full-Year Continuing Appropriations Act, and Administration policy, and after careful analysis and very thoughtful deliberations by a senior management team, in late May 2011, NASA Administrator Bolden decided to accept the Orion-based reference vehicle design, first outlined in NASA's January 2011 report to Congress, as the Agency's MPCV. As part of his decision process, the Administrator determined that the Orion Crew Exploration Vehicle was already being built to meet the requirements of a deep-space vehicle—the current design is sound, and testing has proven the vehicle to be the best option for this phase of exploration efforts beyond low-Earth orbit (LEO). Additionally, the Administrator determined that the Agency's current Orion contractual partnership with Lockheed Martin Corporation maps well to the scope of the MPCV requirements outlined in the NASA Authorization Act of 2010 and, therefore, the current contract will be used at least for the development phase of the MPCV.

At NASA's Johnson Space Center, the Orion Project has continued to progress its development beyond the PDR-level of maturity that was achieved in late 2009. During FY 2010 and FY 2011's period of continuing resolution, Orion adopted an incremental approach to design and development. Work became focused on early test articles, such as the Ground Test Article crew module which was recently completed and is undergoing testing. Further design work has focused on an early flight test configuration to prove out the most critical systems such as parachute and heat shield performance. The vast majority of work performed during the transitional period following the transmission of the President's FY 2011 Budget until present is applicable to the MPCV and has furthered progress toward a beyond LEO capability. In addition, detailed assessments of requirements and candidate architectures for beyond LEO missions have been assessed, with the purpose of ensuring the detailed requirements for the MPCV were understood such that continuing work would be made as applicable as possible.

*Question 3.* In early November 2010, you initiated a parallel series of Requirements Analysis Cycle (RAC) team activities to examine possible alternative vehicle design concepts. Were those teams informed of (a) the performance capability and schedule requirements established in P.L. 111–267, and (b) did they use those requirements as key assumptions on which they based their work?

Answer. As part of an earlier study, the SLS Program researched all of the stakeholder requirements which included the NASA strategic goals, the HEFT study analysis as well as all the Congressional Bills enacted which included the P.L. 111–267 2010 NASA Authorization Act to determine the relevant requirements for SLS program formulation. Key assumptions and goals that were used in evaluating the various RAC SLS options were directly taken from the NASA Authorization Act: (1) the vehicle must be able to initially lift 70–100 tons to LEO, and must be evolvable to 130 tons or more; (2) the vehicle must be able to lift a MPCV; and (3) begin devel-

opment of the SLS vehicle "as soon as practicable after the date of the enactment of" the NASA Authorization Act of 2010 and with the goal of achieving operational capability for the core elements not later than December 31, 2016. Other evaluation criteria used in assessing the SLS RAC options included total Design Development Test and Evaluation (DDT&E) funding required, annual production and operations costs.

*Question 4.* Have you been waiting or been instructed to wait for the results of the RAC activity results before moving out aggressively to modify contracts as they pertain to the MPCV/Orion and the SLS? What is the current status of those RAC activities?

Answer. The Marshall Space Flight Center has completed its internal RAC studies in parallel with 13 complementary studies being conducted by private industry under Broad Agency Announcement (BAA) contracts. The RAC teams delivered their final results the week of February 14, 2011 and the BAA study contractor delivered their final briefing to NASA on April 28, 2011 with the final written report delivery to NASA scheduled on May 23, 2011. A Mission Concept Review (MCR) was also conducted by an independent review team and determined that the SLS program was ready to enter into the Formulation Phase based on providing feasible requirements and budget data.

In parallel with the RAC and BAA studies, NASA has been actively evaluating the existing contracts for Orion and Ares for use in the new MPCV and SLS Programs. NASA has procurement teams who are mapping SLS and MPCV requirements (those outlined in the NASA Authorization Act of 2010 and those we are currently developing) against the Ares and Orion contracts to determine if the new requirements fit the scope of the existing contracts. For the SLS, NASA is reviewing each element of Ares (First Stage, Upper Stage, Upper Stage J–2X engine and avionics) to determine whether the new SLS requirements are within scope of the current contract. For the MPCV, NASA's review of Orion contracts indicated that the MPCV is within scope of the Orion contract, and the NASA Administrator recently made the decision that the Orion contract would be continued for MPCV development. However, final acquisition plans for the SLS are not expected until the summer/early fall timeframe, and will be provided to Congress as soon as it is available.

*Question 5.* How will the RAC study results and conclusions be used in finalizing design concepts for the SLS and Orion/MPCV?

Answer. The final design concept recommendation for SLS extracted the 'best' elements from each of the RAC alternatives and combined them into an integrated strategy for SLS development. It is expected that the final selection of SLS design will have minimal effect on the current MPCV reference vehicle design, since the Orion was originally designed to withstand the Ares I launch profile which was likely more severe that any of the SLS design concepts.

*Question 6.* The 2012 budget request makes a severe reduction below the authorized amounts for the SLS and Orion/MPCV amounting to a combined $1.3 billion less than the amount authorized for FY 2012. What would be the impact on your ability to continue developing these vehicles on any kind of aggressive schedule if that funding level were adopted by Congress?

Answer. It is clear that successful development of SLS and MPCV will be dependent on sufficiently stable funding over the long term, coupled with a successful effort on the part of NASA and the eventual industry team to reduce costs and to establish stable, tightly-managed requirements. While a 2016 operational capability does not appear to be feasible within either projected FY 2012 President's budget request and its out-year funding levels, or within the Authorization Act funding levels, NASA is continuing to explore more innovative procurement and development approaches to achieve operational capability as close to this goal as feasible. In this context, we are still reviewing overall affordability for the longer-term, and alternative design analysis continues to be part of our strategy. Other technical options such as an incremental development approach will be considered based on industry input, innovative methodologies for affordability will be explored, and partnership opportunities will be pursued with other government agencies with the goal of identifying a significant affordability benefit.

*Question 7.* Please explain how the fact that $1.3 billion less was requested for SLS and Orion/MPCV in the FY 2012 Request, while the requested level for Commercial Crew development was increased by $350 million ABOVE the authorized level for FY 2012, does not represent an effort to reverse the respective follow-on launch and crew transportation development priorities established by law in the 2010 NASA Authorization Act systems development and mission support requirements if those funds are no longer under the supervision of the organization responsible for Exploration activities.

Answer. NASA believes that the FY 2012 budget request strikes the right balance between Human Exploration Capabilities and the development of U.S. commercial crew transportation systems to support the ISS and reduce reliance on the Russian Soyuz vehicle. Additionally, all major elements of the Authorization Act are included in the President's budget request.

As the primary means of transportation to the ISS, it is essential that the Commercial Crew Program be successful. We believe the $850 million funding level for commercial crew is necessary to achieve safe, reliable, cost effective crew transportation capability in time to service the ISS. Without the level of funding provided in this budget request, NASA would have to extend its sole reliance on non-U.S. systems for ISS crew transportation. Given that the ISS is being extended to 2020, without the Shuttle, it is essential that we help to develop routine, reliable crew access to the ISS. By helping to develop commercial crew systems, NASA is free to focus on developing beyond-LEO transportation systems. Therefore, NASA has the best of both worlds—routine access to the ISS provided by a commercial provider, while also having the ability to focus its own human spaceflight efforts on beyond LEO exploration—places we haven't been to before.

*Question 8.* As you know, in order to address the concerns of many Members of Congress regarding the seeming desire of the Administration to place complete reliance on new, unproven commercial cargo and crew launch and transportation systems, P.L. 111–267 provided a series of "gates" or enabling steps that must be taken before any such development program is executed. In your view, is it clear to NASA and the Administration that those requirements must be met to the satisfaction of the Congress before any such development program will either be authorized to proceed or receive support for funding through appropriations?

Answer. It is clear to NASA that P.L. 111–267 outlines specific gates related to commercial crew development. These gates include: (1) human rating requirements; (2) commercial market assessment; (3) procurement system review; (4) use of Government-supplied capabilities and infrastructure; (5) flight demonstration and readiness requirements; and, (6) commercial crew rescue capabilities. NASA plans to satisfy all the requirements in the P.L. 111–267.

*Question 9.* Please provide for the record the current status of NASA efforts to ensure compliance with those commercial development requirements.

Answer.

- Item 1, human rating requirements were provided to Congress in December 2010 via the "Commercial Crew Transportation System Requirements for NASA LEO Missions" document;
- Item 2, commercial market assessment was delivered to congress on in April 2011 via the "Commercial Market Assessment for Crew and Cargo Systems" report.
- Item 3, procurement systems review; NASA is currently developing the commercial crew transportation acquisition and procurement strategies. Once these strategies are finalized, NASA will provide Congress a description of the proposed process and justification of the proposed process.
- Item 4, Use of government-supplied capabilities and infrastructure; NASA is currently assessing future infrastructure and capabilities required to support future programs.
- Item 5, flight demonstration and readiness; NASA is developing a human rating process and minimum set performance objectives to be achieved be commercial crew transportation partners. NASA will certify commercial crew transportation providers prior to allowing NASA or NASA sponsored astronauts to fly on any commercial crew transportation system.
- Item 6, commercial crew rescue capabilities; NASA is including crew rescue into the set of commercial crew transportation human rating requirements. NASA will certify commercial crew transportation providers prior to allowing NASA or NASA sponsored astronauts to fly on any commercial crew transportation system.

*Question 10.* Under the 2012 budget request $310 million is taken from Exploration Technology Development program activity and moved to Space Technology, carried under the Aeronautics and Space Technology budget line, and under the control of the Chief Technologist. Please provide an explanation of the justification for this proposed reallocation of funds and how the Committee can be assured that the activities undertaken with those funds will remain guided by exploration systems development and mission support requirements if those funds are no longer under the supervision of the organization responsible for Exploration activities.

Answer. As noted, NASA's FY 2012 budget request moves the majority of content and funding that had been included in the FY 2010 Exploration Technology Development Program (ETDP) from the Exploration Systems Mission Directorate (ESMD) to the Space Technology (ST) theme managed by the Office of the Chief Technologist (OCT). This integration had been proposed in draft FY 2011 appropriations proposals offered in December 2010. NASA agreed with this concept as it would allow for synergy between the activities in Space Technology's Crosscutting Space Technology Development program and the existing efforts funded by ETDP, creating a pipeline for maturing both mission-specific and multipurpose technology.

For traceability, Space Technology has identified these transferred exploration specific technologies under a new program called Exploration Technology Development (ETD). ETD funded activities will continue to focus on the long-range, critical technologies required to carry out future human exploration missions beyond low-Earth orbit and will reduce risk and life cycle cost of these missions. All future activities within this account will also have a human exploration-specific technology demonstration focus. Activities funded through the ETD budget will continue to leverage the existing technical strength of the NASA workforce with at least 70 percent of funds allocated toward directed projects led by the NASA Centers. The ETD and Crosscutting Space Technology Development activities are distinguished by their customer focus, the balance between competed versus guided projects, and cost-share requirements.

By integrating ETDP within Space Technology, the Agency's technology portfolio will be streamlined and strengthened within an organization focused on development and infusion of cutting edge technology. Integrating ETDP into OCT will eliminate the potential for overlap in future technology investments. With management of these investments in an organization focused on technology development, greater attention can be applied to meeting the Agency's beyond LEO technology development priorities.

The ETD activities are critically focused on NASA's beyond LEO mission-specific Exploration priorities. These priorities have been set by ESMD through the HEFT and related planning activities. In FY 2012 and beyond, ESMD will continue to provide prioritized requirements and remain the primary customer for all transferred ETD activities (primarily through the ongoing Human Architecture Team). OCT will manage its ETD activities based on these priorities. In addition, OCT will conduct regular reviews of the ETD projects in implementation. Human spaceflight personnel will be utilized in this review panel. This transfer allows ESMD to focus on Exploration vehicle development, but maintain control of the overall strategy, architecture and technology requirements for future beyond LEO human exploration plans, while allowing OCT to focus on performing the critical technology development and mission infusion activities.

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RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO WILLIAM GERSTENMAIER

*Question 1.* What is the current status of efforts to establish the partnership between NASA and a non-governmental organization to manage ISS National Laboratory-allocated research capability?

Answer. NASA released a Cooperative Agreement Notice (CAN) for an independent non-profit organization to manage the multidisciplinary research carried out by NASA's National Laboratory partners. This organization will: (1) act as a single entry point for non-NASA users to interface efficiently with the ISS; (2) assist researchers in developing experiments, meeting safety and integration rules, and acting as an ombudsman on behalf of researchers; (3) perform outreach to researchers and disseminate the results of ISS research activities; and (4) provide easily accessed communication materials with details about laboratory facilities, available research hardware, resource constraints, and more. On July 13, NASA selected the Center for the Advancement of Science in Space Inc. (CASIS) to develop and manage the U.S. portion of the International Space Station that will be operated as a national laboratory.

*Question 2.* As you know, the underlying rationale for the Congressional designation of the U.S. Segment of the International Space Station as a National Laboratory was to ensure that investigators and researchers in a broad range of scientific disciplines would have assured access to the unique environment of microgravity to conduct experiments. That is also why P.L. 111–267 allocated no less than fifty percent of the U.S. research capacity to the control and use of the non-profit, non-government organization with which NASA is required to undertake a cooperative agreement for management of ISS research. Please describe how these requirements

are being implemented—and that level of utilization protected—under the planned consolidation and reorganization of the Space Operations and Exploration Systems Mission Directorates?

Answer. The planned consolidation and reorganization of the Space Operations and Explorations Mission Directorates will have no effect on the implementation of statutory requirements embodied in P.L. 111–267. NASA is in the process of establishing a dedicated division for "Space Life and Physical Sciences and Applications" within the new Human Exploration and Operations Directorate. This division will include the Human Research Program, Crew Health Systems, Fundamental Space Biology, Physical, and serve as the liaison within NASA for interactions with the non-profit ISS National Laboratory management organization once it is established under a cooperative agreement. NASA anticipates that positioning these diverse areas of research under a single organization will improve communications across disciplines and engender greater synergies across the life and physical sciences community.

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RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO LELAND D. MELVIN

*Question 1.* Mr. Melvin please describe new initiatives or new approaches to NASA Education programs that you have begun to execute or plan to implement.

Answer. In January 2011, President Barack Obama stated that, "over the next 10 years, nearly half of all new jobs will require education that goes beyond a high school education. And yet, as many as a quarter of our students aren't even finishing high school. The quality of our math and science education lags behind many other nations. America has fallen to ninth in the proportion of young people with a college degree. And so the question is whether all of us 'as citizens and as parents' are willing to do what's necessary to give every child a chance to succeed." This speech echoes findings and calls-to-action by numerous committees, reports, professionals in education, and leaders in American industry. In response, the Department of Education has identified several strategies to improve science, technology, engineering and mathematics (STEM) education and ways in which Federal agencies can contribute to the Nation's STEM improvement efforts. NASA is a strong contributor to the national plan.

Consistent with Section 202 of the America COMPETES Reauthorization Act of 2010, NASA works with professional organizations, academia, and state/local education providers to identify and address needs in STEM education. Quality professional development for STEM educators is a prevalent need. Through the education staff at NASA's Centers, NASA works cooperatively with states and school districts to identify content needs and opportunities, and with university partners to ensure that NASA investments will be effective in improving teaching practice. NASA also works through communities of practice to identify content areas and special events that supplement informal education programming offered by museums and science centers. NASA higher education efforts increasingly target community colleges, which generally serve a high proportion of minority students. NASA programs build student STEM ability, preparing students for study at a four-year institution. Competitive opportunities support initiatives like the President's "Race to the Top" and the Department of Education's "Star Project," which promote state-based education reform and identify replicable strategies for improving K–12 education.

NASA's education programs aim to increase the number of students who are proficient in, choose to major in, and pursue careers in STEM fields. Improving STEM ability, increasing public scientific literacy, increasing the talent pool of future STEM workers, and developing the STEM skills of the future workforce are imperatives if the Nation is to remain globally competitive and sustain a strong economy. NASA actively works through mutually beneficial relationships with over 500 colleges and universities, hundreds of K–12 schools and districts, and over 400 museums and science centers to provide education experiences, so that all students can learn deeply and think critically in STEM disciplines. NASA supports cutting-edge undergraduate student research that contributes to NASA missions while training the next generation of scientists, engineers, and innovators. NASA targets recruitment and retention of underserved and underrepresented students, including women and girls, Hispanics, and students with disabilities.

NASA is committed to providing equal access to its education activities by providing any student with the opportunity to contribute to the future STEM workforce. NASA is responding by focusing its education investments on areas of greatest national need and ensuring that the Agency's education programs support national STEM priorities. With its wealth of science and technology content and its expan-

sive network of education professionals, NASA is well equipped to address national needs such as meeting state requirements for educator professional development. NASA provides practical experience and skills development for those who will become the future workforce through internships, fellowships, and student research opportunities. NASA is especially qualified to attract students to pursue STEM study and careers. It also is able to engage these future workers through inspiring NASA missions, fostering collaborative relationships between students and the current workforce and offering students opportunities to work in "out of this world" facilities. Hands-on challenges with expert mentors generate increased interest in STEM study.

NASA has engaged students and teachers in its engineering challenges and scientific discoveries since its inception. From school presentations to seeds flown in space, from filmstrips and posters to podcasts and virtual tours through the galaxies, NASA's education programs have fostered inquiry, built curiosity, and encouraged innovation. Generations of Americans have participated in NASA's STEM education programs, and thereby learned basic skills, discovered new career paths, and developed interests in emerging academic disciplines.

In 2010, NASA chartered an Education Design Team (EDT) to develop a strategy to improve NASA's education offerings, assist in establishing goals, structures, processes, and evaluative techniques to implement new sustainable and innovative STEM education programs. EDT has completed its task, and its recommendations are reflected in the FY 2012 education budget for NASA's Office of Education.

The FY 2012 budget provides NASA with the resources necessary to continue this rich tradition in STEM education through support for the Nation's students and educators, the leveraging of cutting-edge education technologies, and partnerships with industry. The budget proposal will:

- Increase NASA's impact on STEM education by further focusing K–12 efforts on middle school pre-and in-service educator professional development;
- Increase emphasis on providing experiential opportunities for students, internships, and scholarships for high school and undergraduate students;
- Emphasize evaluation and assessment, including external independent evaluation, to ensure that investments are providing desirable STEM impacts;
- Engage strategic partners with common objectives and complementary resources; and
- Use NASA's unique missions, discoveries, and assets (*e.g.,* people, facilities, education infrastructures) to inspire student achievement and educator teaching ability in STEM fields.

*Question 2.* What specific efforts is your organization—or NASA, generally—making to ensure increased and enhanced participation by NASA in interagency efforts to enhance the Nation's competitiveness and capabilities for expansion of academic efforts in Science, Engineering, Technology and Mathematics (STEM) disciplines, as authorized—and required—by the America COMPETES Act?

Answer. NASA is actively engaged in collaborations with other Federal agencies to ensure the Agency's programs are supportive of national STEM priorities. The NASA Associate Administrator for Education represents the Agency on the National Science and Technology Council (NSTC) Committee on STEM Education (CoSTEM). It was established pursuant to the requirements of Sec. 101 of the America COMPETES Reauthorization Act of 2010. The NASA Office of Chief Scientist is also participating in the CoSTEM by providing the CoSTEM Executive Secretary, who works in close coordination with the Office of Education.

The CoSTEM serves as part of the internal deliberative process of the NSTC and provides overall guidance and direction. The NSTC, a Cabinet-level council, is the principal means for the Administration to coordinate science and technology policies across the Federal Government. The purpose of the CoSTEM is to coordinate Federal programs and activities in support of STEM education. In accordance with the Act, the CoSTEM is reviewing STEM education activities and programs, and the respective assessments of each, throughout Federal agencies to ensure effectiveness; coordinating, with the Office of Management and Budget, STEM education activities and programs throughout Federal agencies; and will develop and implement through the participating agencies a 5-year STEM education strategic plan, to be updated every 5 years.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO EDWARD J. WEILER

*Question 1.* Please elaborate on the impact to the Agency's Earth Science mission capabilities as a result of the loss of the Glory satellite. What is the status of the investigation into the proximate cause(s) of that launch or deployment failure? Are there plans to develop replacement vehicle or sensor capabilities on an alternative vehicle, and if so, in what time frame and at what cost?

Answer. The Glory satellite was lost on March 4, 2011, due to a Taurus XL launch vehicle failure. The Glory satellite carried two instruments—the Total Irradiance Monitor (TIM) and the Aerosol Polarimetry Sensor (APS). TIM was designed to measure the amount of solar energy that enters the Earth's atmosphere while APS was designed to identify aerosol composition, scattering properties, and global distribution. Both aerosols and solar energy influence the planet's energy budget—the amount of energy entering and exiting Earth's atmosphere. An accurate measurement of these impacts is important to anticipate future changes to our climate. Given the loss of Glory, NASA must assess if and how to best collect these measurements going forward.

The on-orbit ACRIMSat and SORCE missions continue to provide measurements of total solar irradiance. A next-generation solar irradiance instrument, the Total Solar Irradiance Sensor (TSIS), is in the implementation phase as collaboration between NOAA and NASA. Some limited aerosol measurements are being made by the on-orbit MODIS instruments on Terra and Aqua, the OMI instrument on Aura, the MISR instrument on Terra, and CALIPSO. The VIIRS instruments on NPP and planned for JPSS will have limited capacity for measuring global aerosol distributions, but will not measure the scattering properties that are key to determining the aerosol contributions to the Earth's energy balance. The PACE mission in the FY 2012 President's Budget for flight in 2020 will carry an aerosol instrument, hopefully as an international collaboration with CNES.

NASA currently has no plans to refly a near-identical Glory mission. Owing to its use of the spacecraft bus from the cancelled Vegetation Canopy Lidar mission, which was designed and built more than a decade ago, it would neither be possible nor efficient to build a "carbon-copy" Glory-2 mission today. NASA is, however, continuing to pursue the development and flight of the 14 Earth-observing missions identified in the FY 2012 President's budget request for flight between now and 2020 as well as the competitively selected Venture-class small satellite missions.

NASA is assessing whether it would be scientifically valuable to fly a copy of the APS instrument in 3–4 years and what mission options are possible to fly such an instrument. NASA is currently conducting two studies to address possible options for, and the cost/schedule of, rapid development and flight of a copy of the aerosol polarimetry instrument. The first study focuses on the scientific justification for flying such an APS given the present state of scientific knowledge and the expected availability of supporting on-orbit missions. The second study focuses on the technical/cost/schedule feasibility and implementation of the smallest, lowest-cost mission approach that would meet the science objectives. The results of these studies will inform the Agency's go-forward plan for obtaining data on aerosol composition and scattering properties.

Immediately following the Taurus XL launch failure, NASA established a Mishap Investigation Board (MIB) to investigate the unsuccessful launch. On March 9, 2011, NASA announced the selection of the members of the board. The MIB is scheduled to conclude its investigation no later than September 6, 2011.

*Question 2.* Please provide an update on efforts to ensure timely and cost-effective completion and deployment of the James Webb Space Telescope within the context of the FY 2012 Budget Request and out-year projections? If funding offsets are required from within Directorate programs, what other programs or missions will be impacted, and with what results?

Answer. Currently, we are developing a realistic cost and schedule baseline for the earliest possible launch date for the James Webb Space Telescope (JWST) given the FY 2011 and 2012 budget constraints. The funding constraints for this baseline scenario are the FY 2011 President's budget request ($471 million in FY 2011) and the FY 2012 President's budget request ($375 million in FY 2012), plus unconstrained budgets in out years. This effort required a detailed analysis of all the work that remains to be done including all hardware components as well as a revised integration and test program. This plan will undergo independent review within the Agency and by an outside team of experts to insure adequate budget and schedule. The JWST baseline will be completed this summer and its result will be part of the FY 2013 budget submission.

Using these FY 2011 and FY 2012 funding levels, the project has developed a near-term schedule and milestones for FY 2011 and FY 2012 that will be used to track performance and progress until the new baseline is approved. The JWST project continues to meet its FY 2011 technical and programmatic milestones within cost and on schedule.

NASA's detailed plans for JWST for the balance of FY 2011 are contained in the Operating Plan that was submitted to Congress in June. No decisions have been made on offsets at this time; these will be addressed in the FY 2013 budget submission.

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RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KAY BAILEY HUTCHISON TO WOODROW WHITLOW, JR.

*Question 1.* How are you maintaining or planning to maintain critical infrastructure and workforce capabilities that will support the SLS and MPCV development efforts? What steps are needed to ensure those supporting elements are not lost in the transition from current systems to those follow-on systems?

Answer. The transition from the Space Shuttle Program (SSP) had been an ongoing process for several years, and required extensive detailed planning for critical infrastructure and workforce capabilities requirements. NASA has worked to protect critical capabilities which, if allowed to degrade or lost entirely, could have significant impact on the Agency's ability to support future programs. Through the budget formulation process, the NASA Capabilities Forum has provided a mechanism to assess Agency capabilities and identify those that are required to support a variety of potential future architectures.

NASA also recognizes the need to become leaner and more flexible in its deployment of civil service capabilities. Advanced Exploration Systems (AES) is an important element of this strategy. By utilizing civil service talent to begin development of future exploration capabilities, AES will strengthen the skills and knowledge of our workforce for future human space exploration.

*Question 2.* What steps are being taken to ensure supporting infrastructure and capabilities are maintained or developed to support commercial crew systems development and facility and program integration, especially with respect to ISS operations and sustaining requirements?

Answer. Assessments have been made of what will be required for long-term International Space Station (ISS) integration, operations, and future crew support capabilities for the period during which crew services will be provided by commercial crew contractors. Contractor-specific infrastructure needed to provide the service is assumed to be established and maintained by the contractor under their services costs. This will enable contractors to develop the range of capabilities they need to support future non-NASA customers while also serving NASA customers.

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RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BILL NELSON TO NASA ASSOCIATE ADMINISTRATORS

*Question 1.* Please provide estimated impacts, at each NASA center, for the $298 million cross agency support reductions in the proposed long term House CR (H.R. 1). If these reductions were implemented at the beginning of a Fiscal Year rather than 6 months into it, as these are proposed to be, how would these estimates change?

Answer. The FY 2011 Full-Year Continuing Appropriations Act (P.L. 112–10), which was enacted on April 15, 2011, funds NASA Cross Agency Support (CAS) at the FY 2011 President's Request level. Prior to passage of P.L. 112–10, NASA leadership stated before Congress that the $298 million reduction to NASA's Cross-Agency budget (coming half-way through the Fiscal Year), proposed by H.R. 1, would have an operational impact to the Agency equivalent to the shuttering of two small NASA Centers. No NASA Centers were identified for such an action.

A reduction of $298 million to CAS would have represented more than a 10 percent reduction to the account that funds the management, operations and maintenance of NASA's nine Centers, component facilities and Headquarters. Additionally, CAS funds Agency-wide management functions and conducts safety and reliability activities to assure NASA mission success. Further, had this provision been successfully enacted, the reductions would have occurred so late in the operating year that they would have resulted in thousands of lay-offs to on-site contractors, with 50 percent of NASA's mission support contractor workforce at risk. As the reduction was not included in enacted legislation, the Agency did not proceed to make specific de-

terminations for implementing such direction; however, the contractor impact of a reduction at that level would equate to over 4,500 layoffs across all of NASA's Centers.

If the reductions were implemented at the beginning of the Fiscal Year, the impacts still would be severe. The cuts would result in approximately 2,250 contractor layoffs. We still would have difficulty providing the capabilities necessary to support our Centers.

*Question 2.* How much money has NASA spent since the passage of the NASA Authorization Act of 2010 (P.L. 111–267) that otherwise would not have been due to the prohibition on cancelling Constellation contracts in the FY 2010 Consolidated Appropriations Act (P.L. 111–117)?

Answer. Providing a monetary estimate about how much funding NASA spent since the passage of the NASA Authorization Act of 2010 that otherwise would not have been due to the prohibition on cancelling Constellation contracts in the FY 2010 Consolidated Appropriations Act is not possible, largely because the Administration has not made final decisions with regard to the design and acquisition plans for the new Space Launch System (SLS), as well as support elements for both the SLS and the Multi-Purpose Crew Vehicle (MPCV). Therefore, NASA cannot specifically say, at this time, which Constellation elements will or will not feed forward into the new SLS and MPCV programs, and as such, we cannot accurately estimate how much money could have been saved if not for the funding restriction.

We would like to note, however, that during this time period, NASA was making efforts to focus existing Constellation contracts on work that would likely feed forward to the SLS and MPCV programs—a fact that was recognized by the NASA Inspector General in a letter to Congress on February 2, 2011.

*Question 3.* What steps is the Space Operations Mission Directorate taking to reduce the time required to develop and fly experiments to the International Space Station?

Answer. The International Space Station (ISS) program has implemented the following steps to reduce the time required for science investigators to develop and fly experiments:

- Utilizing a broad agency announcement, the ISS program has selected qualified implementation partners that have experience in the design, development and operation of space hardware, thus reducing the science investigators' need to develop this expertise and technology;
- ISS provides available on-orbit science hardware, facilities, analysis instruments and tools, reducing the need for science investigators to design, build, and certify hardware required to conduct their investigations;
- ISS provides routine conditioned and unpressurized transportation services to and from ISS, dedicated to science cargo, at no cost to the science investigator. Once Commercial Resupply Services (CRS) are available, science investigators could have up to five flight opportunities per year to ISS, which will minimize time impacts due to flight availability;
- ISS provides dedicated on-orbit resources including crew time, volume, power, data, imagery, service gases, and ambient and conditioned storage of samples at no cost to the science investigator. Once commercial crew transportation is available, ISS plans to increase the USOS crew to 4 (total ISS crew of 7) in order to maximize available crew time for research.
- ISS has stratified the payload hardware verification and certification process so that the hardware developers expend the minimum amount of time to ensure their hardware is safe and will operate effectively onboard the ISS.

*Question 4.* Please provide a list of the aeronautics research at NASA that has the potential to reduce fuel consumption and generate savings for the airline industry.

Answer. NASA's Aeronautics Research Mission Directorate is committed to research that promotes fuel efficiency and environmental compatibility while increasing or maintaining aircraft safety. Fuel currently represents the largest operating cost for U.S. airlines. Many of the aeronautics research activities currently being conducted by NASA have the potential, upon adoption, of reducing fuel consumption.

NASA systems analysis indicates that new operational procedures currently in development within the Airspace Systems Program (ASP) have the potential, if fully adopted into the National Airspace System, to reduce fuel burn by 400 million gallons per year during landing and takeoff phases of flight and an additional 200 million gallons per year during the en route cruise phase of flight. These savings cor-

respond to about 3 percent of the annual fuel burned by U.S. commercial airlines. ASP is also developing improvements in ground operations that have the potential to reduce fuel burn during airport taxi operations by 15 million gallons per year, which would result in a reduction of 2 million pounds of $CO_2$ per year of harmful emissions in and around our largest airports. Some key areas of research within the ASP focus on developing new capabilities to:

- Demonstrate near term application of Automatic Dependent Surveillance-Broadcast (ADS–B) enabled technologies to enable fuel and time efficient arrivals (new FY11 initiative);
- Demonstrate near term application of ADS–B enabled technologies to enable efficient surface operations to reduce fuel, noise, and emissions (FY 2012 Presidents budget request);
- Demonstrate Efficient Descent Advisor (EDA) technologies with the FAA 3D–Path Arrival Management (3D–PAM) to enable continuous descent approaches in congested airports for reduced fuel consumption and reduced noise level during landing;
- Demonstrate non-stop taxi surface operations to reduce fuel-consumption due to current stop-and-go throttling operations;
- Optimize efficient arrivals, departures and surface operations through fuel-saving integrated arrival/departure/surface time management, route modification and adaptive speed control;
- Maximize national airspace efficiency with new processes to address demand/capacity imbalances from weather effects and system wide uncertainties to reduce travel time, distance, and delays which inherently reduce fuel consumption and emissions;
- Enable safe, time and fuel efficient, en route flight with varying weather while allowing for reduced distance between aircraft to increase air-traffic volumes; and,
- Reduce airborne and ground hold delays through enabling increases to system capacity by bringing to bear available resources and capacity to wherever demand is surging.

The Fundamental Aeronautics Program (FAP) and Integrated Systems Research Program (ISRP) conduct complementary research aimed at reducing the fuel burn of aircraft. New concepts and technologies undergo early-stage development within FAP. Individual technologies which have matured are then evaluated at an aircraft system level in relevant environments (including flight test) within ISRP. Within these Programs, research is being conducted on technologies that will improve fuel efficiency for a variety of aircraft and have a direct effect on overall fuel consumption for the aircraft industry. Specific areas of research include:

- New aircraft designs and configurations, including rotorcraft and subsonic vehicles, that are more efficient;
- Lightweight structural components, such as airframes, to reduce subsonic aircraft operating empty weight;
- Advanced fuel-efficient engine designs;
- Ways to reduce subsonic aircraft drag, with minimal impact on operating empty weight, for total aircraft energy reduction; and,
- Some advanced structural and propulsion-related material research intended primarily for supersonic aircraft applications will also benefit subsonic aircraft by helping to reduce vehicle and propulsion system weight thereby reducing fuel consumption.

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## RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARK WARNER TO NASA ASSOCIATE ADMINISTRATORS

**The promise of commercial space:**

*Question 1.* I have always been interested in innovative ways of financing infrastructure, including by leveraging private sector dollars and by helping to harness the competitive and entrepreneurial spirit that drives innovation in our private sector. I believe commercial spaceflight has the potential to save NASA a great deal of money by offering lower-cost options for missions that NASA currently must pay a lot of money for. Can you talk about the potential for savings NASA can achieve through partnerships with private-sector entrepreneurs, and describe how NASA can foster a business-friendly climate that will further encourage entrepreneurs?

Answer. Through our current commercial cargo and crew public-private partnership agreements, NASA is fostering an environment that harnesses the competitive and entrepreneurial spirit with U.S. emerging as well as established companies to develop and demonstrate new space transportation capabilities. With respect to financing infrastructure, we have seen innovative ways partners meet resource and infrastructure needs as they develop their space transportation systems.

By supporting the development of systems and capabilities targeted toward providing commercial services, NASA has enabled providers to determine how best to meet the needs of their eventual customers. A combination of NASA seed money, facilities and technical expertise along with existing partner infrastructure and innovation has resulted in the beginning of a vibrant new commercial space transportation industry.

NASA's commercial cargo development project (COTS) is an excellent example of the cost savings that can result from innovative public-private partnerships. This cost savings is described in Appendix B of the recently released "Commercial Market Assessment for Crew and Cargo Systems," which described an analysis performed by NASA showing the dramatic cost savings achieved in the development of the Falcon 9 launch vehicle.

NASA will continue to foster a business-friendly climate by partnering with industry to understand government and industry needs and enabling development of new systems and capabilities. The goal is to achieve reliable cost effective solutions that become available to NASA, other Government entities, and private sector customers. These partnerships hold the potential to open new markets in space, increase high technology jobs in the United States, as well as reduce development and operations costs compared with traditional NASA program practices.

**Fixed-price and cost-plus contracting:**

*Question 2.* Can you describe NASA's position on fixed-price versus cost-plus contracting? As I understand it, one of the exciting features of the Commercial Crew Program, a feature that saves money for the taxpayer, is the use of fixed-price agreements. Can you describe some of the advantages of fixed-price commercial procurement?

Answer. NASA's approach to contract type selection is to match the unique circumstances of the procurement with the appropriate acquisition mechanism. Given the nature of NASA's mission, many of our procurements are for complicated research and development efforts that involve complex requirements where the likelihood of changes makes it difficult to estimate performance costs in advance. Consequently, due to these complex requirements, significant technical risk, and cost uncertainty, a cost type contract is appropriate in such cases. Typically, as a program matures the risk shifts and contract types should also shift toward firm-fixed price contracts which are more advantageous to the government since they shift a substantial portion of the cost risk to the contractor, thus heavily incentivizing the contractor to control costs.

NASA's Procurement Tenets were published on August 1, 2008. One of the tenets is "Reducing Cost and Cost Risk for Procurements," which states in part that cost risk for each requirement must be properly allocated between NASA and industry. Commercial item procurements result in fixed-price contracts and thus shift a substantial portion of the cost risk onto the contractor. For example, NASA pursued a commercial contracting model for the ISS Commercial Resupply Services (CRS) contracts. These competitive, firm-fixed-price, multiple award ID/IQ contracts will provide commercial cargo resupply services to and from the International Space Station.

The acquisition strategy for the Commercial Crew Program (CCP) has not been finalized at this time. Careful consideration is being given to the appropriate acquisition mechanism for this important program and several reviews are scheduled in the next two months to address the approach for our procurement strategy. NASA is also incorporating lessons learned from CRS and other programs. We recognize the advantages of commercial and other types of fixed-price contracts, where appropriate, and will fully consider their use for CCP.

International Competitiveness on the Launch Market:

*Question 3.* As you know, thirty years ago, the United States has a commanding lead in the international launch market—we launched a number of payloads for other countries. But today, we've lost most of our market share to China, India, Russia, and Europe. The Commercial Crew Program would invest new resources in the commercial spaceflight sector, which would improve America's competitiveness in the global launch market. How do you think NASA could best work with commercial providers, not just to launch people into space, but also to recapture our lead in the international launch market?

Answer. NASA can best work with commercial partners to help recapture our lead in the international launch market by partnering with industry to understand Government and industry needs and enabling development of new systems and capabilities with the goal of achieving safe, reliable, and cost effective solutions that are available to NASA, other Government entities, and private sector customers. Key factors for customers in the launch market are reliability and affordability.

*Question 3a.* How essential is the Commercial Crew Program to ensuring the future of the International Space Station? Also, what is the program's importance to how we get Americans into space and to the International Space Station with the retirement of the space shuttle?

Answer. The Commercial Crew Program is essential to ensuring the future of the International Space Station (ISS), and NASA plans to facilitate the development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable and cost effective access to and from Low Earth Orbit (LEO) and the ISS after the retirement of the Space Shuttle. Once the commercial crew transportation capability is matured and available to customers, NASA plans to purchase transportation services to meet its ISS crew rotation and emergency return obligations. The Agency anticipates the availability of these systems by the middle of the decade, contingent upon the availability of appropriated funding.

In the meantime, NASA intends to continue to purchase seats aboard the Russian Soyuz spacecraft until demonstrated commercial crew transportation services and rescue services are available in order to maintain a U.S. presence on the ISS and to satisfy U.S. obligations to its non-Russian ISS partners. Once U.S. commercial transportation services become available, NASA plans to purchase 8 commercial crew seats per year (4 seats twice a year) in order maximize ISS utilization. The Agency plans to have a period of time where crew transportation and rescue services provided by Russian and U.S. commercial vehicles overlap to ensure no gap in services. The current exception to the Iran, North Korea and Syria Non-Proliferation Act (INKSNA) for extraordinary payments to Russia for the International Space Station (ISS) allows the Agency to purchase or barter for Russian seats and other services to July 1, 2016.

It is important that the Agency look to commercial providers to sustain the ISS so that NASA can focus its efforts on developing systems designed to carry astronauts on missions of exploration beyond LEO. This will also have the effect of encouraging the development of crew transportation services that could be purchased by other users, as well.

**STEM Education and Commercial Space:**

*Question 4.* As you are well aware, the commercial spaceflight sector has been attracting substantial attention from the media and the public. A few weeks, ago there was a major piece in the New York Times with the title "Space Tourism May Mean One Giant Leap for Researchers," talking about how scientists and educators can benefit from low-cost commercial spaceflight. What do you see as the ability for commercial spaceflight providers to inspire young people to pursue careers in science, technology, engineering, and math (STEM) careers? As you know, many of our young people are captivated by the idea of being able to travel to space. How can NASA tap this energy and work with the commercial spaceflight sector to keep exciting students?

Answer. NASA has a rich history of providing exciting opportunities for students to pursue payload and flight project opportunities including historically successful projects such as the Reduced Gravity Education Flight Program, and more recent opportunities such as the High Altitude Student Platform (HASP), BalloonSat High ALtitude Flight (BHALF) competition, the University Student Launch Initiative (USLI) competition, High Schools United with NASA to Create Hardware (HUNCH) and the CubeSat Launch Initiative.

Per the requirements of the America Competes Reauthorization Act of 2010 (PL 111–358; Sec 205), NASA will continue to study and assess the potential impacts on science, technology, engineering, and mathematics (STEM) education of a program that would facilitate the development of scientific and educational payloads involving United States students and educators and the flights of those payloads on commercially available orbital platforms, when available and operational, with the goal of providing frequent and regular payload launches.

The recent NASA-chartered Education Design Team (EDT) report recommended that the NASA Education program place increasing emphasis on providing experiential opportunities for students, internships, and scholarships for high school and undergraduate students; and engage strategic partners with common objectives and complementary resources.

NASA has been given Congressional direction to pursue activities through the International Space Station (ISS) National Laboratory Education (NLE) project which leverage the resources of entities external to NASA, including commercial companies, academic institutions, not-for-profit organizations and other U.S. Government agencies. Collaborative educational activities directly partnered with, or in conjunction with, the ISS Program International Partner space agencies are included in the expansion of ISS educational activities.

Under the ISS National Lab and ISS NLE concept, commercial payloads such as the Commercial Generic Bioprocessing Apparatus (CGBA) Science Inserts, the Synchronized Position Hold Engage and Reorient Experimental Satellite (SPHERES), and Space Dynamically Responding Ultrasonic Matrix System (Space-DRUMS) are poised for additional partnering opportunities and expansion of their educational activities. Some of these payloads will expand their educational scope to incorporate content applicable in the both the Kindergarten through 12th grades (K–12) as well as at the University level. Activities to include international student participation as well as students from traditionally underrepresented and underserved institutions will also be emphasized and considered part of an expansion opportunity.

Commensurate with the NLE goals, the NanoRacks ISS National Lab payload (also known as CubeLab), offers flight opportunities for K–12 schools and Universities to conduct experiments of their own design within the NanoRacks facility. The NanoRacks hardware is developed by NanoRacks LLC in partnership with Kentucky Space, an ambitious non-profit enterprise focused on R&D, educational and small entrepreneurial and commercial space solutions involving several Universities in the state of Kentucky.

The Flight Opportunities program, managed by the Office of the Chief Technologist, helps foster the development of the commercial reusable suborbital transportation industry, an important step in the longer-term path that envisions suborbital reusable launch vehicles evolving to provide the Nation with much lower-cost, more frequent, and more reliable access to orbital space. The Flight Opportunities program will competitively secure commercial suborbital flight services and extend the opportunity for flights through a competitive process. By reducing the cost of suborbital flights, researchers and students will have increased access to testing payloads in a reduced gravity environment. The program has already provided contracts to Armadillo Aerospace and Masten Space Systems to provide developmental test flights. One of these vendors will provide flights for the Excelsior STEM mission, a commercial unmanned suborbital mission sponsored by Teachers in Space and scheduled to fly in 2011. Experiment kits for the Excelsior STEM mission will be assembled by teachers at a Suborbital Flight Experiment Workshop to be held August 1–5, 2011 at the NASA Dryden Flight Research Center's AERO Institute in Palmdale, California. NASA hopes to make more opportunities available as more commercial suborbital flights are scheduled.

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### RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. JOHN BOOZMAN TO DOUGLAS R. COOKE

*Question.* As you know, the 2010 NASA Authorization Act requires NASA to use innovative and non-traditional costing, schedule and procurement strategies in formulating its plans for implementation of the required developments of the Space Launch System (SLS) and the Multi-Purpose Crew Vehicle (MPCV). This was done to ensure that NASA could implement and expedite development activities for those systems in an affordable and sustainable manner within a limited resources environment. Can you describe what innovative or alternative approaches have been considered and planned for implementation in the SLS and MPCV development activities, and how they contribute to the viability, affordability and sustainability of those vehicles?

Answer. Industry discussions with prime and sub-contractors, and review of data from the heavy lift Broad Agency Announcement (BAA) study contracts showed that large cost reductions can be realized through innovative management approaches and contract vehicles that give clear requirements and allow the contractor to find and deliver solutions using industry standards and processes Both SLS and MPCV are actively challenging the heritage cost structure and redefining the Programs to become more entrepreneurial/affordable. For example, the MPCV Program has met with the Orion prime and all of its major sub-contractors to discuss cost/schedule drivers and common themes for affordability. During those discussions, the team identified and adopted many processes and values such as implementing a development strategy that adopts "learn early and inexpensively" principles; right-sizing reporting requirements, streamlining joint decision making processes, employing an

incremental (metered) development approach including proposed early flight tests; streamlined facility approaches for integrated testing, and distributed and proto-flight qualification. Another major affordability approach being implemented is a change in organizational processes and values to shift the focus more onto adaptability, affordability and speed. This will be accomplished by NASA insight/oversight reform—deploying a smaller/flatter organization, streamlined deliverables and decision processes, and adopting vertical integration in key development, management and manufacturing areas.

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RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO WILLIAM GERSTENMAIER

*Question 1.* ISS research is about to move into full swing. Can you please describe how research on the ISS has grown to date and indicate some of the most important discoveries which impact human on Earth?

Answer. The International Space Station (ISS) is now fully assembled, and includes three major international science laboratories: the U.S. Destiny, European Columbus, and Japanese Kibo labs. During Expeditions 0–24 (from September 2000 to October 2010), 1,149 investigations were conducted aboard Station (including 454 completed investigations, 734 International Partner investigations, and 25 National Laboratory pathfinder investigations (NOTE: data as of January 20, 2011). This work involved more than 1,600 scientists and has resulted in more than 310 scientific publications (international count ongoing). In FY 2010 alone, astronauts aboard ISS conducted over 250 Station-wide research experiments, including 150 U.S. experiments, supporting the work of over 400 scientists world-wide.

In addition to conducting research in support of future human missions into deep space, astronauts aboard the ISS carry out experiments anticipated to have terrestrial applications:

- ISS research has shown that bacteria can become more virulent in microgravity (*i.e.,* more aggressive in causing disease). In several cases, scientists have successfully identified the genes responsible for this increased virulence and are now developing vaccine candidates. AstroGenetix, Inc. has funded their own follow-on studies on ISS and is now preparing to submit Investigational New Drug applications to the Food and Drug Administration for the treatment of both salmonella-induced food poisoning and methicillin-resistant Staphaureus (MRSA).
- Microcapsules are tiny micro-balloons used in cancer treatment to deliver anti-cancer drugs directly to a tumor site. Microcapsules with improved cancer treatment properties developed on the ISS were reproduced on Earth and were successful in targeting delivery of anti-cancer drugs to successfully shrink tumors in ground tests. A device to produce similar capsules on Earth has now been patented, and clinical trials of the drug delivery method are planned at M.D. Anderson Cancer Center and the Mayo Clinic.
- A Japanese scientist crystallized the HQL–79 protein (human prostaglandin D2 synthase inhibitor protein) on the ISS, producing an improved structure that identified the location of critical hydrogen bonds that were not previously known. This allowed drug design for a candidate treatment to inhibit the progression of Duchenne muscular dystrophy. Continuing work is looking at other proteins and viruses.
- Numerous plant growth experiments have investigated both the effects of microgravity, as well as the capability for growing regenerable food supplies for crew. Technology developed for a greenhouse flown on the ISS is now widely used on Earth, killing 98 percent of airborne pathogens (including Anthrax) for food preservation, doctors' offices, homes, and businesses.

Research into areas such as biotechnology, bioengineering, medicine, and therapeutic treatment will be enabled by the National Laboratory function of the Station. NASA has five Memoranda of Understanding (MOUs) with other U.S. government agencies, and nine agreements with non-government organizations to conduct research aboard the ISS. NASA intends to continue to expand the community of National Laboratory users of the ISS. In support of this effort, on February 14, NASA released a Cooperative Agreement Notice (CAN) for an independent non-profit organization to manage the multidisciplinary research carried out by NASA's National Laboratory partners. This organization will: (1) act as a single entry point for non-NASA users to interface efficiently with the ISS; (2) assist researchers in developing experiments, meeting safety and integration rules, and acting as an ombudsman on behalf of researchers; (3) perform outreach to researchers and disseminate the re-

sults of ISS research activities; and (4) provide easily accessed communication materials with details about laboratory facilities, available research hardware, resource constraints, and more. On July 13, NASA selected the Center for the Advancement of Science in Space Inc. (CASIS) to develop and manage the U.S. portion of the International Space Station that will be operated as a national laboratory.

*Question 2.* What steps are being taken to ensure the availability of up mass and down mass to private companies or commercial entities to enable and further expand ISS utilization?

Answer. The ISS has transitioned from the construction era to an operations and research era, with a six-person permanent crew, three major science labs, and an operational lifetime through at least 2020. The ISS represents a unique research capability, aboard which NASA, other Government agencies, commercial entities, and partner nations can conduct a wide variety of research in biology, chemistry, physics and engineering fields. NASA anticipates that this research will support future human missions into deep space, and have terrestrial applications.

In order to provide cargo transportation to and from ISS—for the Agency and for users of the Station in its capacity as a National Laboratory—NASA will depend on U.S. industry to provide commercial resupply services (CRS) following the retirement of the Space Shuttle. On December 23, 2008, NASA awarded CRS contracts to Orbital Sciences Corporation (OSC) and SpaceX for the delivery of cargo to the ISS after the retirement of the Shuttle. The CRS contractor will provide an end-to end service to deliver, and return or dispose of ISS cargo. NASA anticipates that both providers will have their systems operational in 2012.

NASA ordered 12 CRS flights valued at $1.59 billion from SpaceX.

- SpaceX will provide pressurized and unpressurized upmass and return services.
- SpaceX currently has currently completed 14 funding milestones for the four CRS missions in process. In addition, one more CRS mission may be turned on if progress continues. Finally, two milestones in support of COTS demonstration cargo have been paid.
- The first SpaceX CRS flight is currently scheduled for late January 2012, and the company is currently slated to fly three CRS missions each Fiscal Year from 2012 through 2015.

NASA ordered eight CRS flights valued at $1.88 billion from OSC.

- OSC will provide pressurized upmass and disposal services.
- OSC has currently completed 11 funding milestones for three CRS missions. Finally, 2 milestones in support of COTS demonstration cargo have been paid.
- The first OSC CRS flight is currently scheduled for the end of the first quarter of calendar year 2012, and the company is currently slated to fly two CRS missions each Fiscal Year from 2012 through 2015.

These commercial services are planned to help support U.S. operations and utilization of the ISS to meet NASA mission objectives, NASA obligations for international utilization cargo under the ISS Memoranda of Understanding (MOUs), and the needs of other civil and commercial users of the Space Station. Additional proposed funding for cargo to support U.S. National Laboratory users was included in the President's FY 2012 budget request.

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RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. JOHN BOOZMAN TO LELAND D. MELVIN

*Question.* The Arkansas Space Grant Consortium has participated in NASA's Experimental Program to Stimulate Competitive Research (EPSCoR) for 10 years. What kind of impacts can they expect from the President's FY 2012 Budget Request?

Answer. The President's budget request for FY 2012 reflects the need to develop a balanced education portfolio for the Agency that supports its efforts in higher education, K–12 student and teacher programs, and informal education.

NASA anticipates offering a competition in FY 2012 for EPSCoR Research Awards and plans to continue the opportunity for states to participate in the Research Infrastructure Development component of NASA EPSCoR. Arkansas NASA EPSCoR will be eligible to participate in both of those opportunities.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN BOOZMAN TO DR. JAIWON SHIN

*Question 1.* With your essentially flat budget, how are you further increasing investments into new materials, composite structures, and structural analysis tools which have been showing benefits to the aviation and aerospace industries?

Answer. NASA currently conducts research on materials, composite structures, and structural analysis within both the Fundamental Aeronautics Program (FAP) and the Integrated Systems Research Program (ISRP) within Aeronautics Research. New concepts and technologies undergo early-stage development within FAP. Individual technologies which have matured are then evaluated at an aircraft system level in relevant environments (including flight test) within ISRP.

Recognizing and responding to a growing use of new materials and composite structures, beginning in FY 2012, NASA will be increasing the investment in new materials, composite structures and structural analysis tools. NASA research will focus on the development of new Ceramic Matrix Composites (CMC) materials with increased temperature capabilities and models to understand them. Additionally, composites structural analysis capabilities will be improved and expanded with the creation of new tools to support the design of advanced airframes (including those that have come from the recent advanced aircraft concepts studies). Examples of improved capabilities will include analysis of multifunctional structures and science based analysis of safety factors. Ultimately this may lead to safer and lighter structures with improved damage tolerance characteristics and a reduction in testing time.

In a related area, NASA will also be expanding research into the lightning effects, sensors, and related damage on composite materials. Adequate damage models for the effects of lightning strikes on composites do not currently exist. Further, existing sensor and mitigation methods are low maturity and/or heavy resulting in weight penalties on aircraft. The expanded research activity would accelerate the development of standardized test procedures from FY 2013 to FY 2012 and demonstrate multifunctional sensors that protect and diagnose composites to meet FAA requirements in FY 2013. At the same time, funding was reduced for lower priorities, including hypersonics.

*Question 2.* What other strategic investments are you making? In what areas of research or infrastructure and how do you expect these investments to benefits NASA and the United States?

Answer. NASA Aeronautics fully supports the National Aeronautics Research and Development Policy and Plan, in which strategic investments by the U.S. government are identified, in order to ensure our technological leadership in the aeronautics enterprise is maintained and strengthened. Investments being made by NASA Aeronautics cover areas including mobility through the air in order to best support the realization of the Next Generation Air Transportation System (NextGen), safety of flight, air vehicle and air traffic operations, energy efficiency, and minimizing the effect of aviation on the environment. With regards to infrastructure, we continue to support the ground testing and experimental flight research capabilities of the Agency and the Nation through strategic management of assets as wind tunnels, engine test cells, materials and structures laboratories and a variety of subsonic and supersonic aircraft. With the FY 2011 appropriation, we have started new efforts in several areas, including providing technology-based solutions to ease the integration of unmanned aircraft systems into the national air space and in the development of new approaches for verifying and validating the proper function and operation of increasingly complex air vehicles and air traffic management systems.

In FY 2012, NASA is focusing its efforts on areas that directly support U.S. strategies for realizing safer and more efficient flight. These include increased research into efficient and safe airport surface operations. Technologies will be integrated from the current NASA portfolio to further advance greater utilization of Automatic Dependent Surveillance—Broadcast (ADS–B) application technologies providing optimization of airport surface movements with precise scheduling to reduce surface and en-route traffic delays and enhance safety. Research into high altitude ice crystal effects on aircraft engines will be increased to improve the probability that NASA's capability will support the Federal Aviation Administration's new rule-making and thus increase aviation safety for the community in a timely manner. Alternative fuels research will be increased to help advance our understanding of the emissions characteristics of these new fuels (including biofuels) as their use in aircraft increases, which is a key factor in substantially reducing the impact of aviation on the environment—specifically reducing the gaseous and particulate emissions of aircraft. Also beginning in FY 2012, NASA will be increasing the investment in new

materials, composite structures and structural analysis tools. The primary focus of this effort will be in the development of new Ceramic Matrix Composites (CMC) materials with increased temperature capabilities and models to understand them Additional research will be conducted into the effects of lightning strikes on composite materials.

This research will accelerate development of standardized test procedures to support development of sensor concepts, advanced models, and protection methods. NASA Aeronautics Research has a long history of directly benefiting the Agency, as our in-house aeronautical sciences expertise is brought to bear on agency efforts ranging from the design of launch vehicle system to the development of materials that allow safe atmospheric entry/re-entry of both manned and unmanned capsules and science mission landers. More so though, the taxpayer investment through NASA in aeronautics research primarily benefits the U.S. economy and the general public. The strategic investment that we are making in FY 2012 will ensure that the overall benefits to the U.S. economy that are realized through safe and efficient flight operations continue to be realized into the future. The ultimate benefit of NASA developed knowledge and technologies is realized when U.S. industry develops superior products aided by NASA research results and collaboration with NASA in a fiercely competitive global market, which will not only maintain but advance U.S. aviation industry's pre-eminence in an increasingly global enterprise.

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## NASA Administrator Selects Orion-based Design for MPCV Development Phase

NASA has reached an important milestone in defining the next transportation system that will carry humans into deep space in accordance with the NASA Authorization Act of 2010, the FY 2011 Full-Year Continuing Appropriations Act and Administration policy. While NASA is down-selecting and further focusing options for developing the heavy-lift Space Launch System (SLS) within the Agency, NASA has reached an important milestone with regard to our path forward on the Multi-Purpose Crew Vehicle (MPCV). After careful analysis and very thoughtful deliberations by a senior management team, Administrator Bolden has decided to accept the Orion-based reference vehicle design, first outlined in NASA's January 2011 report to Congress, as the Agency's MPCV.

As part of his decision process, the Administrator determined that the Orion Crew Exploration Vehicle was already being built to meet the requirements of a deep-space vehicle—the current design is sound, and testing has proven the vehicle to be the best option for this phase of exploration efforts beyond low-Earth orbit (LEO). Additionally, the Administrator determined that the Agency's current Orion contractual partnership with Lockheed Martin Corporation maps well to the scope of the MPCV requirements outlined in the NASA Authorization Act of 2010 and, therefore, the current contract will be used at least for the development phase of the MPCV.

Moving forward, work on the MPCV will focus only on the deep-space design. While the MPCV could be called upon to service the International Space Station (ISS)—a backup requirement established by the NASA Authorization Act of 2010—it should be well understood that utilizing the MPCV would be a very inefficient and costly use of the MPCV deep-space capability. NASA is confident in the ability of our commercial partners to provide all currently foreseen support for the ISS. Therefore, there is no intention to conduct routine LEO missions with the MPCV.

It is important to point out that the Administrator's decision regarding MPCV does not reflect a "business as usual" mentality for the Agency. Over the last year, the NASA/Lockheed Martin team has shown exceptional creativity in finding ways to keep costs down by implementing new management techniques, technical solutions and innovation within the Orion Project. Examples include implementation of a new oversight model to ensure the most efficient use of NASA and contractor workforce and applying technology such as composite materials, friction stir welding and advanced avionics networks to enhance performance as well as affordability . . . and that's just the beginning. These innovations have allowed the Orion team to continue technical progress within reduced budget estimates.

In the coming weeks, NASA will be making further decisions with regard to transportation architecture. In the meantime, NASA is refining the SLS concept and defining strategy alternatives based on detailed Government analysis and completed input from industry through Broad Agency Announcement study contracts. Additionally, the MPCV team is focusing on further development of the Ground Test Article, other development design and analysis, as well as coming up with an integrated MPCV/SLS plan that will be affordable, sustainable and realistic. Due dili-

gence will ensure the best value for the taxpayer with respect to cost, risk, schedule, performance and impacts to critical NASA and industrial skills and capabilities.

Further details about NASA's analysis and decisions regarding SLS and MPCV and their path forward will be provided to Congress in a follow-on report in the late spring/summer timeframe. But even when that report is submitted to Congress, work will remain ahead for the Agency, particularly as we finalize development plans and acquisition decisions per normal Agency processes—decisions that must remain consistent with NASA's Strategic Plan and Agency commitments. For example, NASA will need to hold a Procurement Strategy Meeting to approve the specific details for each individual procurement action.

In conclusion, NASA remains committed to meeting the goals and requirements of the NASA Authorization Act of 2010, and we look forward to working with Members of Congress as we finalize our plans for achieving human spaceflight exploration of multiple destinations in our solar system.