NASA'S FISCAL YEAR 2011 BUDGET REQUEST AND ISSUES

HEARING

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

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February 25, 2010

NASA'S FISCAL YEAR 2011 BUDGET REQUEST AND ISSUES

THURSDAY, FEBRUARY 25, 2010

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Committee met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Bart Gordon [Chairman of the Committee] presiding.

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, DC 20515

Hearing on

NASA's Fiscal Year 2011 Budget Request and Issues

February 25, 2010
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

WITNESS LIST

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

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HEARING CHARTER

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

NASA's Fiscal Year 2011 Budget Request and Issues

THURSDAY, FEBRUARY 25, 2010
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose:

On Thursday, February 25, 2010 at 10:00 a.m., the Committee on Science and Technology will hold a hearing on the National Aeronautics and Space Administration's (NASA) Fiscal Year (FY) 2011 Budget Request and Issues.

Witness:

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

BACKGROUND INFORMATION

Overview

The National Aeronautics and Space Administration (NASA), which was established in 1958, is the nation's primary civil space and aeronautics R&D agency. The estimated Civil Service Full-Time Equivalent (FTE) workforce level for FY 11 is 18,354. NASA has ten field Centers, including the Jet Propulsion Laboratory (JPL), a federally Funded Research and Development Center (FFRDC). NASA conducts research and development activities in a wide range of disciplines including aeronautics, astrophysics, heliophysics, planetary science, Earth science and applications, human space flight, microgravity research, and technology development. NASA also operates a fleet of three Space Shuttles and is completing assembly of and operating/utilizing the International Space Station (ISS). NASA has also had a program underway to develop a new crew exploration vehicle and crew launch vehicle system to enable U.S. access to the ISS after the retirement of the Shuttle and to enable crewed missions beyond low Earth orbit, including working towards the goal of returning Americans to the Moon by 2020. NASA also maintains a space communications network that supports both NASA missions and other user requirements. As of fiscal year 2008, the most recent date for which complete data are available, about 83 percent of NASA's budget was for contracted work. In addition, a number of NASA's scientific and human space flight activities involve collaboration with international participants.

The rollout of the President's FY 11 request for NASA included limited information, and the detailed budget justification document was not available to Congress until this past weekend. This hearing is intended to examine the key policy changes proposed in the budget request as well as issues raised by those changes. The Committee's Subcommittee on Space and Aeronautics plans to hold additional hearings to examine the Administration's request in more detail.

NASA Budgetary Information

NASA's proposed budget for FY 11 is $19 billion, an increase of 1.5 percent over the enacted FY 10 appropriation of $18.7 billion for NASA. Funding for NASA is projected to increase by an average of 2.5 percent per year from FY 12 through FY 15. Attachment 1 summarizes the FY 11 budget request and its five-year funding plan. Attachment 2 provides an overview on the extent to which the FY 11 budget proposal responds to the NASA Authorization Act of 2008 [P.L. 110–422]. It should be noted that in FY 09, the American Recovery and Reinvestment Act [P.L. 111–5] included $1 billion for NASA's Earth science, aeronautics, and exploration programs, cross-agency support, and Inspector General. Recovery Act funds are to be expended by September 30, 2010.

The structure of the accounts presented in the FY 11 budget request remains largely the same as in the FY 10 budget request with the exception of two changes. Pursuant to language in the Statement of Managers of the Consolidated Appropriations Act, 2010, the proposed NASA budget combines and organizes funding for repair or modification of NASA facilities, construction of new facilities, and managing of environmental clean-up from individual Directorates into a new account-Construction and Environmental Compliance and Restoration. In addition, the President's request for NASA adds a new advanced space technology initiative in an account with aeronautics research that is entitled, "Aeronautics and Space Research and Technology."

NASA and the Administration's Overall FY 2011 Budget Request

In the context of the overall Federal budget, NASA's average annual percentage of total budget authority from FY 1976–FY 2009 [which excludes the Apollo era], is 0.79 percent and the average annual percentage of total discretionary budget authority over the same time period is 2.05 percent. The percentage share of the budget devoted to NASA has declined from this average over the past ten years, and the FY 11 request for NASA would decrease NASA's share of total budgetary authority to 0.51 percent and its percentage of the total discretionary budget authority down to 1.50 percent. If one applies the 2.05 percent historical average to the total Federal discretionary budget authority of $1.26 trillion in the Administration's FY 11 budget request, the result would be a NASA funding level in FY 11 of approximately $25.9 billion.

Key Changes and Initiatives from FY 10 Budget Proposal

Human Spaceflight

In its FY 10 Budget request, the Administration maintained the Congressionally-authorized policy of returning Americans to the Moon:

"*The Agency will create a new chapter of this legacy as it works to return Americans to the Moon by 2020 as part of a robust human and robotic space exploration program*."

The FY 11 request for NASA no longer maintains a return to the Moon as the next step in human spaceflight and exploration.

With regards to a post-Shuttle human launch system and commercial services for cargo and crew delivery to the International Space Station, the FY 10 budget request for NASA stated that "*Funds freed from the Shuttle's retirement will enable the Agency to support development of systems to deliver people and cargo to the International Space Station and the Moon. As part of this effort, NASA will stimulate private-sector development and demonstration of vehicles that may support the Agency's human crew and cargo space flight requirements*." In contrast, the FY 11 request for NASA "*funds NASA to contract with industry to provide astronaut transportation to the International Space Station as soon as possible, reducing the risk of relying solely on foreign crew transports for years to come*."

The FY 11 request for NASA proposes the following for NASA's human spaceflight activities:

- Cancels the Constellation Program and provides a total of $2.5 billion for FY 11 and FY 12 for close-out costs and contract termination;
- Initiates three new technology development lines within the Exploration Systems Mission Directorate focusing on:
  - Flagship Technology Demonstrations that have a stated goal of reducing costs and increasing capabilities for future exploration ($652 million in FY 11),
  - Heavy-lift and propulsion research and development ($559 million in FY 11), and
  - Robotic precursor missions described as being developed to identify potential locations for exploration and demonstrate technologies to increase safety ($125 million in FY 11);
- Invests $6 billion on the development of commercial human spaceflight over five years;
- Increases the Space Shuttle Program budget by $600 million in FY 11 to fund the safe completion of the Space Shuttle manifest into the first quarter of FY 11, if needed; and
- Provides an additional $429 million in FY 11 for "21st Century Space Launch Complex."

The FY 10 budget proposal stated that "*NASA will fly the Space Shuttle to complete the International Space Station . . .*" In addition, it said that "*NASA will continue to assemble and utilize the International Space Station, the permanently crewed facility orbiting Earth that enables the Agency to develop, test, and validate critical space exploration technologies and processes.*" No mention was made of extending ISS operations. In its FY 11 request for NASA, the Administration proposes extending ISS operations and increasing utilization: "*The President's Budget provides funds to extend operations of the Space Station past its previously planned retirement date of 2016. . . . NASA will maximize return on this investment by deploying new research and test technologies in space and by making Space Station research capabilities available to educators and new researchers.*"

Specifically, the FY 11 request for NASA's International Space Station Program includes:

- An increase of $463 million over the FY 10 enacted budget (and $231.6 million over the amount requested for the ISS in the President's FY 10 budget proposal) and an increase of $2 billion from FY 11–FY 14 as compared to the FY 10 budget request to be used for supporting the ISS National Laboratory and increasing Station capabilities, according to NASA's FY 11 budget overview materials.
- The FY 11 budget will cover the transportation costs to and from the ISS to support ISS research conducted by National Laboratory users. The previous plan was to require National Laboratory users to pay for their own transportation costs.

Science

The FY 11 request for NASA's Science Mission Directorate continues to make Earth science and climate change research a priority, following the emphasis placed on these areas in the Administration's FY 10 budget proposal. Key changes for NASA's Science programs include:

- A proposed increase of $300 million in FY 11 for Earth observations and climate satellites and research, largely for the reflight of the Orbiting Carbon Observatory (OCO), a scientific mission slated to monitor global carbon sources and sinks that was lost in a February 2009 launch failure;
- Requests funds to restart, in a cost-sharing arrangement with the Department of Energy (DOE), the production of plutonium-238 to support future exploration missions; and
- Initiates a high-priority solar probe mission.

Aeronautics

- Proposes increases of $73 million for FY 11 for aeronautics, which includes funding for NASA's Environmentally Responsible Aviation project.

Education

- Requests $20 million in FY 11 for new STEM education pilot projects.

Space Technology

- Requests $572 million in FY 11 to initiate a new agency-wide program to develop and test advanced space technologies.

PROGRAM AREAS

Human Space Flight

With its release of the FY 10 budget request for NASA, the Administration announced the establishment of an independent review of NASA's human space flight activities. In addition, the FY 10 budget request proposed a total cut of over $3 billion from NASA's Exploration Systems budget over five years, relative to the FY 2009 budget plan. The Administration indicated that an updated request would be forthcoming pending the outcome of the review. The Review of Human Spaceflight Plans Committee, chaired by retired Lockheed Martin executive Norman Augustine, delivered its final report in October 2009. The overarching conclusion of the review was that "*the U.S. human spaceflight program appears to be on an unsustainable trajectory*." The committee maintained that "*Meaningful exploration beyond low-Earth orbit is not viable under the FY 2010 budget guideline*" and that "*Meaningful human exploration is possible under a less-constrained budget, increasing annual ex-*

penditures by approximately $3 billion in real purchasing power above the FY 2010 guidance." For FY 11, the President's request includes $4.3 billion for Exploration Systems, a reduction of $1.8 billion from the budget plan for Exploration in FY 11 that was included in the FY 10 budget request runout. The Administration's proposed plans for future human spaceflight activities were included as part of its FY 11 budget request for NASA. The FY 11 budget request includes limited details on the plans.

Constellation

As part of its request for Exploration, the Administration proposes to cancel the Constellation Program, which consists of the Ares I crew launch vehicle and Orion crew exploration vehicle, the Ares V heavy-lift launch vehicle, associated ground systems, and lunar systems. Constellation was the architecture established to deliver Americans to the ISS and later to the Moon and other destinations in the solar system following the retirement of the Space Shuttle. As of January 2010, NASA reported that it has spent a total of about $9 billion on Constellation. In the Statement of Managers accompanying the FY 10 Consolidated Appropriations Act, "*The conferees note that the Constellation program is the program for which funds have been authorized and appropriated over the last four years, and upon which the pending budget request is based. Accordingly, it is premature for the conferees to advocate or initiate significant changes to the current program absent a bona fide proposal from the Administration and subsequent assessment, consideration and enactment by Congress*." The Statement of Managers also states that "*Funds are not provided herein to initiate any new program, project or activity, not otherwise contemplated within the budget request and approved by Congress, consistent with section 505 of this Act, unless otherwise approved by the Congress in a subsequent appropriations Act. Funds are also not provided herein to cancel, terminate or significantly modify contracts related to the spacecraft architecture of the current program, unless such changes or modifications have been considered in subsequent appropriations Acts*." Similar language was included in the Act itself.

The President's FY 11 request for NASA includes a total of $2.5 billion for FY 11–FY 12 in "close-out costs" for Constellation and any additional costs for Shuttle transition.

In its place, the President's request focuses on supporting the development of commercial capabilities to deliver crew to the ISS and on developing innovative, advanced technologies, among other proposed activities.

Some of the issues and questions raised by the proposal include the following:

- In discussing the potential to use commercial services to transport crew to low-Earth orbit, the Augustine Committee report stated that "there are simply too many risks at the present time not to have a viable fallback option for risk mitigation." However, in proposing a major investment in the development of commercial crew capability, the FY 11 request does not include a fallback option. What is the rationale for the decision not to include a government-led crew transport system development program as a "fallback option"?
- The FY 11 budget request does not propose a concrete plan or mission for human exploration beyond low-Earth orbit or development of a heavy-lift launcher to enable such exploration. Therefore, in proposing commercial crew services for low-Earth orbit, the Administration in essence relinquishes U.S. government capability to send humans into space after the Shuttle is retired for the foreseeable future. What would be the implications of relinquishing the U.S. government capability to launch humans into low-Earth for the maintenance of specialized technical skills, facilities, industrial base capabilities, national security, global competitiveness, and geopolitical standing? To what extent were these issues considered in formulating the proposal to pursue commercial crew services?
- With the retirement of the Space Shuttle and the cancellation of all of the Constellation contracts occurring at the same time under the Administration's proposal, and the inevitable gap that will occur in the awarding of any new contracts for alternative activities due to the time required for such contracts to be developed, competed, and negotiated, what will the impact be on the aerospace workforce that had been working on Shuttle and Constellation? How many workers will be affected, and to what extent was disruption to the workforce considered in the formulation of the Administration's human space flight plans?
- What is the plan for the disposition of facilities constructed to support and develop the Constellation Program?

- What implications does the proposed cancellation of Constellation have for other Federal agencies, such as the Department of Defense's (DOD) space industrial base? To what extent were the Administration's plans for NASA's human space flight program vetted with other agencies such as DOD before a decision was made?

Commercial Crew and Cargo

The request includes a total of $812 million in FY 11 and a total of about $6 billion for FY 11–FY 15 for commercial space flight as part of NASA's Exploration Systems Mission Directorate funding. The total includes a request of $500 million in FY 11 for fostering the development of commercial companies to deliver crew to the ISS and proposes $312 million in FY 11 for "additional incentives" for NASA's existing Commercial Orbital Transportation Services (COTS) program, which is supporting commercial development of vehicles to deliver cargo to the ISS. According to NASA, no decisions have been made on whether NASA would use a Space Act Agreement or other mechanism to implement a commercial crew program. In addition, according to NASA officials, no decisions have been made on the cost-sharing, if any, that commercial companies would be required to contribute to a commercial crew development program; the level of safety requirements they would be expected to meet; or the level of non-government market the commercial business plans would be expected to support. NASA also is unable to provide at this time a timetable for when NASA would have a demonstrated capability from potential commercial providers that would allow the agency to actually procure commercial crew services to low-Earth orbit.

To provide the full scope of NASA's current and proposed support for commercial spaceflight activities, NASA's Space Operations Mission Directorate awarded Commercial Resupply Service (CRS) contracts in December 2008 valued at a total of about $3.5 billion to provide commercial cargo services to the International Space Station. The awards were made to Space Exploration Technologies (SpaceX) and Orbital Sciences Corporation in advance of any demonstrated capability by the companies to actually deliver cargo to the ISS. In addition, NASA plans to support a Commercial Reusable Suborbital Research (CRuSR) project to "*competitively secure flight services for experimental payloads supporting NASA's objectives in science, technology and education*" according to NASA's Fiscal Year 2011 Budget Estimates book. At present, no commercial reusable suborbital launch vehicle services are in existence. NASA plans to support commercial spaceflight as part of its Facilitated Access to the Space Environment for Technology Development and Training (FAST) project, which "*provides opportunities for emerging technologies to be tested in the space environment thereby increasing their maturity and the potential for their use in NASA programs and in commercial applications*" according to NASA's Fiscal Year 2011 Budget Estimates book. "*The FAST project promotes the growth of emerging commercial space services by employing competitively selected private reduced gravity flight services*."

Some of the issues and questions raised by the commercial crew and cargo proposals include the following:

- How was the estimate of $6 billion for development of commercial crew derived?
- What is the basis for cost savings assumed to be accrued from commercial crew services?
- What contingencies are in place should a commercial crew provider's business fail and shut down?
- On what basis does NASA estimate that commercial crew services will be available by 2016?
- What is the basis for proposing a $312 million "incentive" for the COTS program, given that the companies involved already have the incentive of a total of $3.5 billion for the follow-on contract? How will the proposed funding be used?
- Who assumes the liability for astronauts or researchers transported on commercial crew vehicles?
- In the absence of an alternative government system, what recourse will the government have if commercial crew vehicles are unable to attain the safety standard set by NASA?
- In the absence of an alternative government system, how will the pricing of the commercial crew transport services be set and enforced?

- How many jobs is NASA assuming will be created by the proposal to seek commercial crew services to support the ISS? What is the basis of those assumptions?

Advanced Technology Development

The FY 11 budget request initiates three technology and R&D programs in the Exploration Systems Mission Directorate.

- Exploration Technology and Demonstrations Program

  The President's request proposes $652 million in FY 11 and a total of $7.8 billion to fund an "Exploration Technology and Demonstrations" program. The program will support Flagship Technology Demonstrations, projects at the level of $400 million to $1 billion over less than five years to demonstrate technologies such as in-orbit propellant transfer and storage, inflatable modules, and closed-loop life support systems, among other activities. The proposed program will also support an Enabling Technology Development Program to consist of smaller and shorter duration projects at the level of $100 million or less. Those projects are expected to be competitively selected and will demonstrate key technologies such as in-situ resource utilization and advanced in-space propulsion. NASA has indicated that it is developing a plan for the program. There are no details on how the projects would be prioritized or selected and what NASA would expect as "deliverables" for these projects. In addition, it is not clear at what point NASA would expect to have the capabilities in hand, based on the technology development programs, to make a determination on a target, mission, plan and architecture for a human exploration mission beyond low-Earth orbit.

- Heavy-Lift and Propulsion Technology

  The proposed FY 11 budget for NASA's Exploration programs includes $559 million in FY 11 and $3.1 billion for the FY 11–FY 15 period to support space launch propulsion technology research and development. NASA indicates that it intends to develop a new RD–180 class hydrocarbon rocket engine with funds from this account, but it has not yet articulated the requirement for such an engine. The projects may involve intra-governmental, commercial, academic and international partnerships.

- Exploration Precursor Robotic Missions

  The budget proposal requests $125 million in FY 11 and $3 billion over FY 11–FY 15 to develop and deploy robotic precursor missions to locations such as the Moon, Mars and its moons, Lagrange points and nearby asteroids. It is unclear how the missions, e.g., to Lagrange points, would differ from previous robotic spacecraft missions, or what the urgency of those missions would be in the absence of a timetable for human missions to those locations. According to NASA budget materials, the program will support missions costing $800 million or less.

Several issues and questions raised by the Exploration Technology and Development program proposals include the following:

- What was the basis for the budget numbers proposed for these programs?
- What are the goals and milestones for technology development?
- In the absence of an overarching vision and concrete mission, how will these technologies be applied?
- In the absence of an overarching vision and concrete mission, what is the risk that technology development funds will be used to support other objectives?
- What are the requirements against which advanced technology developments will be conducted and what are the metrics to measure progress?
- NASA budget materials indicate that part of the purpose of these technology programs is to reduce the costs and increase the capabilities of space activities. How does NASA plan to establish metrics for the cost reductions to be accrued and the enhanced capabilities to be achieved? What are the criteria for success?
- The former robotic precursor program was conceived with lunar exploration in mind. How will the funding for the program be prioritized given the wide range of potential activities it will undertake?
- There is scientific interest in all of the potential targets the robotic precursor missions might explore. What is the role of the Science Mission Directorate

(SMD) in this activity? To what extent will this program leverage SMD's long-term experience in robotics and the potential target areas listed?

- One proposed activity for the robotic precursor program is to land a robot on the Moon that can be remotely operated and that can transmit near real-time video from the Moon. What would be the justification for such a project when the Google Lunar X Prize, which is a private activity, has nearly identical objectives?
- As NASA seeks to broaden its technology development programs and include participation, to some extent, from international partners, what are the challenges? To what extent will information security and International Traffic in Arms Regulations (ITAR) pose issues for the programs and how will NASA address those challenges?

Space Shuttle

The proposed FY 11 budget request includes approximately $989 million for the Space Shuttle Program, an increase of about $600 million over that requested in FY 10 for the FY 11 Shuttle Program. The increases support the completion of the Shuttle manifest into the first quarter of FY 11, if necessary. If the manifest is completed by the end of FY 10, NASA indicates that it will work with the Administration and Congress to prioritize use of the additional funds. Once the flights are completed, NASA will augment its work on transition and retirement of the Shuttle.

Under the Constellation Program, NASA was in the process of leveraging workforce synergies between Shuttle and Constellation and planned to transfer many Shuttle civil servants to Constellation. With the proposed shift in NASA's direction, the Shuttle Program will evaluate whether some of the Shuttle workforce could be tasked to new initiatives, including technology demonstration programs.

Some issues and questions related to the Shuttle Program include the following:

- The 2009 Annual Report of the Aerospace Safety Advisory Panel notes that "*Successful workforce transition depends heavily on a decision being made about NASA's direction*." What steps is NASA taking to ensure the workforce remains focused on safely flying out the Shuttle manifest at a time when the proposed direction for NASA in the FY 11 request largely eliminates a government follow-on to the Shuttle and does not include funding for work on a heavy-lift launcher?
- The Augustine Committee noted the importance of maintaining critical workforce skills and capabilities such as the design and manufacturing of solid propellant motors. To what extent does NASA's proposed redirection affect those critical skill areas and what, if any, plans does NASA have to address this issue? To what extent is NASA identifying other skills used in the Shuttle and Constellation programs that should be preserved as critical national capabilities?
- How much time can lapse before the U.S. cannot access the critical skills needed to develop and operate a heavy-life vehicle?
- How will decisions be made on the disposition of Shuttle orbiters to external institutions? What are the criteria for those decisions?

International Space Station

As part of its FY 11 budget proposal for NASA, the Administration supports the extension and utilization of the ISS: "*The President's Budget provides funds to extend operations of the Space Station past its previously planned retirement date of 2016 . . . NASA will maximize return on this investment by deploying new research and test technologies in space and by making Space Station research capabilities available to educators and new researchers*." To support the extension and increased utilization of the ISS, the Administration requests approximately $2.8 billion for the ISS in FY 11, an increase of about $463 million over that enacted in FY 10 and an increase of about $230 million from that projected for FY 11 in the FY 10 budget submission. The Augustine Committee, among other external advisory bodies, noted the importance of extending ISS operations and utilization. In addition, the NASA Authorization Act of 2008 directed NASA to "*take all necessary steps to ensure that International Space Station remains a viable and productive facility . . . through at least 2020*." According to NASA officials, the decision to extend ISS operations is critical to the agency's ability to plan for utilizing the ISS National Laboratory, decision making and planning with international partners, and working to plan for future cargo transportation needs.

The NASA Authorization Act of 2005 designated the ISS a National Laboratory for use by the private sector and other Federal entities. According to NASA, up to

50 percent of ISS research capability may be available to support non-NASA users. NASA has engaged in National Laboratory partnerships with the National Institutes of Health and the Department of Agriculture. NASA has also entered into Space Act Agreements with private companies. Research that is ongoing or planned as part of the National Laboratory includes vaccine development, telemedicine, environmental testing among other research areas. Many of the systems and research being demonstrated are intended to have significant ground-based applications. The President's FY 11 request includes funding to pay for the transportation costs required to support National Laboratory user research on the ISS. This proposal represents a departure from the FY 10 plan, which was to require ISS National Lab users to cover their own transportation costs for accessing the ISS.

Several issues and questions related to the future of the ISS include the following:

- What are the implications and contingencies for ISS utilization should the availability of commercial cargo transportation services be delayed considerably?
- How will internal NASA users—Exploration, Science, Space Operations—determine their own priorities?
- The NASA Authorization Act of 2008 directed NASA to "*identify the organization to be responsible for managing United States research on the International Space Station . . .*" A recent Government Accountability Office (GAO) report, "International Space Station: Significant Challenges May Limit On-orbit Research" also noted that other large research institutions include a research management entity. What are NASA's plans for a research management organization?
- Who or what organization will determine the priorities for National Laboratory research conducted on the ISS as well as who gets access to available transportation capacity?
- The GAO also noted that "*NASA's staff members in ISS fundamental science research areas have been decentralized or reassigned, limiting its capability to provide user support*." What are NASA's plans for rejuvenating interest in ISS fundamental science research areas?
- In comparing NASA ISS with other major research laboratories and institutes, GAO found NASA's outreach to potential users limited. What are NASA's plans to enhance user outreach?
- Other issues relate to NASA's reliance on commercial cargo transportation service, e.g., to what extent do cargo providers understand user requirements and are they planning to meet them?

21st Century Space Launch Complex

The President's proposal for FY 11 includes $429 million in FY 11 and a total of about $2.1 billion from FY 11–FY 15 for a 21st Century Space Launch Complex at Cape Canaveral [run by the USAF] and Cape Kennedy. To date, NASA has provided only limited details on what might be involved, the goals included in overview budget materials include increasing the operational efficiency of the Center and reducing launch costs for NASA and other launch site users, including commercial cargo service providers.

- What was the process used to identify infrastructure at Cape Canaveral as a priority as opposed to another NASA facility?
- To the extent that funds are used to reduce launch costs for commercial cargo service providers, will those providers reduce their planned prices to carry government cargo or otherwise share in the cost of the improvements?
- What is the basis of the estimate of $429 million in FY 11 and $2 billion total to support the modernization?
- What is the basis of the requirement for the 21st Century Launch Complex in the wake of the proposed cancellation of the Ares launch vehicle programs?
- To what extent, if at all, has this proposed initiative been coordinated with DOD?
- What assumptions is NASA making about the outcomes from this project in terms of efficiency, throughput, cost savings, etc.?
- What are the priorities for spending the $429 million within the FY 11 year?
- What is the target completion date, and would there be any potential disruption or risk to ongoing launch services during the upgrade?
- When will detailed plans be available for this project?

- Why is this project not included in NASA's facilities and maintenance budget line and prioritized against other NASA facilities needs?

Earth Science

The President's budget for FY 11 requests $1.8 billion for Earth science research, applications, Earth observing missions, education and outreach, and technology development, an increase of about $380 million over the FY 10 enacted budget. The runout for FY 11–FY 14 proposed in the budget represents an increase of about $1.8 billion as compared to the FY 10 request's runout. According to the Budget of the U.S. Government Fiscal Year 2011, the budget proposal for Earth science "*accelerates the development of new satellites the National Research Council recommended as Earth Science priorities*" thereby continuing support for Earth science missions provided in the FY 10 request. The Administration's proposal also "*supports several research satellites currently in development, a campaign to monitor changes in polar ice sheets, and enhancements to climate models. In addition, the Budget provides funds for NASA to develop and fly a replacement for the Orbiting Carbon Observatory, a mission designed to identify global carbon sources and sinks that was lost when its launch vehicle failed in 2009*."

The FY 10 appropriation for NASA provided $15 million to continue studies of the second pair of Earth Science decadal survey missions—the Climate Absolute Radiance and Refractivity Observatory (CLARREO) and the Deformation, Ecosystem Structure, and Dynamics of the Ice (DESDnyI) mission to be implemented. Of the 15 missions recommended for implementation by NASA, two missions—the Soil Moisture Active-Passive (SMAP) and the Ice Satellite II (ICESat)—have entered the formulation phase, CLARREO and DESDnyI are in the concept study phase.

Other Earth Science Program Areas

The proposed FY 11 budget request includes increases through FY 14 for Earth Science technology to provide new and enhanced capabilities and measurements, for example, while the Multi-Mission Operations line remains essentially flat. Over the FY 11–FY 15 budget horizon, the budget plan includes modest increases for NASA's Applied Sciences program involving the development of decision support tools that apply the research results of NASA's Earth science missions to support other Federal agency and institutional missions in the areas of climate, ecosystems, agriculture, water, disaster management and other areas that benefit society. How or to what extent NASA will use the Applied Sciences Program for decision support for stakeholders, especially in the area of climate change, is a potential issue to explore in the hearing.

National Polar-orbiting Operational Environmental Satellite System

In addition, the Administration's FY 11 budget proposes a major restructuring of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) which was structured as an integrated tri-agency program to meet civil and military requirements for environmental data. The restructuring will involve dissolving the NASA–National Oceanic and Atmospheric Administration (NOAA)–DOD tri-agency Integrated Program Office and relegating responsibilities for portions of the program to NOAA/NASA and DOD. The three agencies will continue to coordinate their roles in environmental satellite observations. NOAA and NASA would have responsibility for the afternoon orbit of the program in what is called the Joint Polar Satellite System. DOD would have responsibility for the early morning orbit and existing European and DOD assets would be expected to continue providing other coverage. NOAA would exercise its ongoing relationship with NASA to procure instruments and spacecraft bus elements. The NASA budget request for FY 11 does not include any budget impacts as a result of this restructuring, however the changes are expected to have implications for NASA as it assumes procurement responsibility for significant elements of the former NPOESS program.

Key Issues for Earth Science include the following:

- In FY 10 the Administration requested increases of more than $1.2 billion over the FY 09–FY 13 period, including Recovery Act funds, for "accelerating" Earth Science Decadal Survey and foundational Earth science missions. Where are we now and how much acceleration has been accomplished as a result of these investments? How much "acceleration" is the United States buying with the proposed FY 11 increases for decadal survey missions?
- To what extent are Decadal survey missions reflecting the scope of science identified in the Decadal survey and to what extent are measurements being

included? Who has the "say" in determining the scope (which affects cost) of the Decadal survey missions?

- To what extent are the "foundational missions" making adequate progress toward meeting launch readiness dates?
- What are the implications of funding the OCO reflight for the plans for implementing Decadal survey missions? To what extent are groups discussing and planning to demonstrate the use of OCO data for verifying potential climate agreements that may be negotiated in the future?
- Does NASA plan to participate in NOAA's Climate Services initiative and if so, how? To what extent, if at all, will NASA's Applied Sciences program be involved?
- What are the implications of the NPOESS restructuring for NASA? Will NASA have sufficient acquisitions staff in place to manage the significant contracts for instruments and spacecraft buses that NASA will handle on behalf of NOAA?

Space Science

The President's FY 11 budget requests $3.2 billion (not including Earth science) to fund NASA's space science programs, including Heliophysics, which seeks to understand the Sun and how it affects the Earth and the solar system; Planetary Science, which seeks to answer questions about the origin and evolution of the solar system and the prospects for life beyond Earth; and Astrophysics, which seeks answers to questions about the origin, structure, evolution and future of the universe and to search for Earth-like planets. The FY 11 budget request for space science represents a decrease of about $44 million below the amount requested for space science in FY 10, and a reduction of about $171 million for FY 11–FY 14 from the projections in the FY 10 budget proposal. Over the FY 11–FY 14 period, the Astrophysics budget is increased by about $111 million, the Planetary Science program is reduced by approximately $57 million, and the Heliophysics budget decreases by about $225 million, as compared to the FY 10 budget projection for FY 11–FY 14. The FY 11 proposal also requests funds to move forward on the Solar Probe Plus mission, a high priority mission recommended in the National Research Council's decadal survey on solar and space physics.

During 2009, NASA's space science program launched Kepler, a mission to search for Earth-sized planets near distant stars, the Wide-field Infrared Survey Explorer (WISE), which will scan the sky in the infrared spectrum and also detect asteroids, the Lunar Reconnaissance Mission, which is mapping the lunar surface, the Lunar Observation and Sensor Satellite (LCROSS) that impacted a crater and confirmed the presence of water in the permanently shadowed crater. NASA also completed the fifth human servicing mission of the Hubble observatory since its launch in 1990.

The FY 11 budget proposal for NASA proposes to restart U.S. production of plutonium-238, which is needed to support power sources for deep space missions and other exploration activities. The U.S. ceased production of the Pu-238 material decades ago and has lately been purchasing the material from Russia. The availability of future Russian supplies, however, is highly uncertain. NASA's budget information does not include details on the roles and responsibilities of NASA and DOE or how much is being requested for NASA to support restarting Pu-238 production.

Key issues for space science include:

- The availability and cost of launch vehicles are major factors in planning, designing and budgeting for space science missions. The cost of launch vehicles appears to be rising, the major medium-class workhorse—the Delta II—is no longer available for future missions, and excess ballistic missiles whose engines are used for a family of launchers are in limited supply. What are the implications of this situation for NASA's science program? What is NASA doing to address this situation?
- To what extent will the FY 11 budget plan give NASA flexibility to budget for new missions, especially those to be recommended in the NRC's astronomy and astrophysics and planetary science decadal surveys?
- The 2008 NASA Authorization Act directed the Administrator to "*establish an intra-Directorate long-term technology development program for space and Earth science . . . for the development of new technology*." The FY 11 request for NASA proposes new initiatives and major investments of several billion dollars for advanced technology, however, none of the new initiatives specifically responds to the Congressional direction. What is the rationale for not establishing an intra-Directorate technology program in SMD?

- In recent years, some of NASA's science missions have experienced considerable cost growth and schedule delays. To what extent, if any, has SMD considered any new approaches in types of spacecraft, instruments, or mission planning to help address issues related to cost growth?
- How, if at all, does SMD plan to participate in the Space Technology program? What types of technology developments would SMD see as candidates for the program? What does SMD believe will be its contributions to the Agency's emphasis on innovation?
- What, if any, implications does the proposed extension of the ISS have for SMD? What potential opportunities for science does the ISS extension make possible?
- What role, if any, does SMD envision playing in the precursor robotic program?
- What are the implications, if any, of the proposed cancellation of Constellation on SMD?
- What are the implications for SMD, if any, of the President's proposal to rely on commercial crew and cargo services to LEO?
- How much will NASA spend on plutonium-238 restart and what will it be used for? What are the roles, responsibilities, and cost-sharing between NASA and DOE for restarting plutonium-238? How sustainable is the funding over the out-years?
- The FY 11 request includes increases to detect asteroids that could pose hazards to Earth. How will those increases be used and to what extent will this funding help make progress on the congressional direction to detect, track, catalogue, and characterize 90% of near-earth objects 140 meters in diameter or larger?

Aeronautics Research and Space Technology

For FY 11, NASA is requesting $1.51 billion for aeronautics and space research and technology of which about $580 million is requested for aeronautics and $572 million for a Space Technology budget line.

Aeronautics Research

NASA's aeronautics program has and continues to conduct fundamental and systems-level research to enable technical capabilities and economic benefits for the aviation industry and the nation. The goals of the program are 1) to carry-out advanced, cutting-edge research that will yield benefits for the aeronautics community and 2) to develop the concepts and enabling technologies that involve systems-level approaches.

The FY 11 proposal increases aeronautics by $73 million over the FY 10 enacted budget and by $300 million over the FY 11–FY 14 period as compared to the FY 10 budget projections.

The additional budget for aeronautics will support new initiatives that would augment NASA's contribution to the Next Generation Air Transportation System (NextGen). NextGen is a joint effort between the Federal Aviation Administration (FAA), NASA, DOD, Department of Homeland Security and Department of Commerce that will transform the entire national air transportation system, gradually allowing aircraft to safely fly more closely, reduce delays, and provide benefits for the environment and the economy through reductions in carbon emissions, fuel consumption, and noise. Specifically the FY 11 proposal includes:

- An increase of $20 million to initiate a grants program as part of NASA's environmentally responsible aviation program,
- An increase of $20 million to support work on verifying and validating software-based systems, and
- An increase of $30 million to support issues related to incorporating unmanned aircraft systems in the national airspace.

Issues for Aeronautics Research include:

- Is NASA's research and development program able to address important issues related to aviation's impact on the environment, e.g., noise, emissions, and energy consumption, under current funding levels?
- How effectively is NASA's aeronautics research and development program supporting the Nation's NextGen initiative?

- How can NASA work more effectively with industry, universities and colleges to carry out a meaningful aeronautics research and development program?

Space Technology Program

The FY 11 request proposes a new Space Technology Program, which is bookept under a programmatic line now called Aeronautics and Space Research and Technology. The request includes $572 million in FY 11, an amount that is projected to increase to over $1 billion in FY 12 and remain at that level through FY 15. In addition, the Space Technology Program aims to strengthen U.S. leadership in various research areas, and foster the development of future-oriented, long-term capabilities. The program will include the Innovative Partnerships Program (IPP), which was formally located within the Cross-Agency Support program. The Space Technology Program will expand partnerships with academia, industry, other Federal agencies and international institutions.

The establishment of a Space Technology Program responds to recent NRC reports, as well as the Augustine Committee report, that have called for reinvigorating NASA's role in advanced technology. The Subcommittee on Space and Aeronautics held a hearing to examine the results of NRC reviews and other issues regarding advanced technology development at NASA. The FY 11 budget request for the Space Technology Program does not include details on how NASA plans to implement the program, including what the milestones, criteria for success, and measures of progress will be.

Issues for Space Technology include:

- What is the basis for the amount being requested for this program?
- To what extent does the absence of an overarching mission such as returning humans to the Moon affect the urgency, focus, and criteria for success for the space technology program?
- The FY 11 request provides several hundreds of millions of dollars (excluding the Innovative Partnership Program funding) in new money to be spent within the first year of the program's life. How realistic is it to assume that a new program in its first year of existence will be able to properly set priorities and goals, establish solicitations, vet the solicitations, and make selections in a manner that will efficiently and effectively spend those dollars?
- What plans and safeguards are needed to effectively double the size of the program after the first year?
- How are priorities for the projects to be established?
- Will all of the funding be competed and, if not, what proportion will be spent at NASA Centers?
- How is NASA defining "game-changing innovations"?
- NASA notes that the program seeks to increase the capability and affordability of space activities. In this regard, what is a reasonable contribution to expect from the projects this program will fund?
- To what extent has NASA considered whether cost-sharing or financial contributions will be part of the partnerships with commercial, other Federal agencies, or external institutions that it will be pursuing to conduct advanced technology development activities?

Space Communications

The President's FY 11 budget requests $485 million for Space Communications and Navigation, about $54 million less than the amount projected for FY 11 in the FY 10 request and $32 million less than the enacted FY 10 budget. NASA has largely completed acquisitions to replenish aging Tracking and Data Relay Satellite (TDRS) spacecraft, which are used to support communications and tracking for the International Space Station (ISS), Space and Earth science missions, as well as other Federal Government agencies. During the next year, NASA will determine whether or not it will procure an additional two TDRS spacecraft.

The FY 11 budget request includes plans for NASA's Space Communications and Navigation program to begin procuring 34 meter antennas as upgrades to the three 70 meter antennas that comprise the Deep Space Network (DSN). The DSN supports continuous communications to spacecraft in orbit. The DSN is 40 years old, many of its subsystems are obsolete, and the GAO has raised concerns about its fragility and continuing ability to service a mounting workload. The 34 meter antennas will be linked as an array. The Program's goal is to complete the 34 meter upgrades to the DSN by 2025. The existing DSN 70 meter dish located in Goldstone, CA includes a radar capability that is critical for characterizing near-Earth objects and

accurately determining their orbits. According to NASA officials, the requirements for the new 34 meter antenna array include the radar capability.

Issues for Space Communications include:

- In light of proposed changes to NASA's exploration strategy which add robotic precursor missions, are NASA's long-range plans for modernizing its space network adequate to handle the higher workload?
- What is NASA doing to alleviate the aging of the infrastructure supporting the Deep Space Network?

Education

The President's budget requests $145.8 million in FY 11 to support NASA's Education program. The request represents a reduction of about $38 million from the FY 10 enacted budget. The most notable change in the FY 11 request is the focus on using NASA's education programs to encourage innovation, including innovative approaches in STEM teaching and education through the use of NASA resources and content. As part of this theme, the President proposes a budget of $20 million in FY 11 to support the Summer of Innovation, a pilot project being launched in FY 10 to target at least 100,000 underperforming middle school students and to reach 5,000 STEM educators over the summer vacation and during other opportunities. The funds will be competed and managed through the Space Grant consortia.

In FY 10, NASA plans to introduce as a pilot project the redesign of the Explorer Schools project, which works with selected schools to deliver NASA content to middle and high school students, to provide professional development, and to increase student engagement and proficiency in STEM areas. The NASA Authorization Act of 2008 directed a review of the Explorer Schools project. The redesigned Explorer Schools project will be *"open to all secondary schools and will utilize current technologies in the delivery of opportunities and experiences to meet the needs of today's learning and learners*," according to NASA's Fiscal Year FY 2011 Budget Estimates book. The President's FY 11 request proposes about $8 million each year for the FY 11–FY 15 budget horizon.

In addition to the programs included in NASA's Office of Education, the Science Mission Directorate, the Aeronautics Mission Directorate, the Exploration Systems Mission Directorate, and the Space Operations Mission Directorate as well as the NASA Centers all fund educational projects. The Office of Education coordinates education activities across the NASA and its Centers.

Issues and questions related to the Education program include the following:

- What will NASA tell students and America's youth about what it is doing and where it is going? How important is their response?
- What is the increase for the Summer of Innovation actually supporting and is there sufficient lead-time for NASA and institutions to effectively initiate the pilot project for the Summer of 2010?
- How will the results of the 2010 Summer of Innovation pilot projects guide spending decisions for the $20 million requested in FY 11?
- What are the implications of the proposed cancellation of the Constellation Program for NASA on its education programs and the ability to inspire youth to pursue STEM or space-related education and careers?
- Some of NASA's educational programs, projects, and student competitions directly reflect the goals of returning humans to the Moon, developing a new crew launch and exploration vehicle to get there, and potentially creating a lunar infrastructure. Does NASA have any plans to alter those projects to reflect the Agency's new direction?
- Students' decisions on education, studies, and potential careers, even in the pre-college years, may be shaped by their perceptions of long-term, concrete programs that will support them should they pursue a particular path. The President's FY 11 plans for human spaceflight do not specify a target, a timeline, or a particular program for human exploration beyond low-Earth orbit. Does this pose any risk of losing America's best and brightest students to other technical and scientific fields?
- NASA has long used visits to Shuttle launches as a means to inspire students and Americans in support of the Nation's space program. What, if anything, will replace this unique opportunity for outreach?

NASA Infrastructure: Construction and Environmental Compliance and Restoration

NASA's institutional investments are intended to ensure that facilities and field installations can meet the agency's mission requirements in a safe, secure and environmentally sound manner.

According to NASA's Fiscal Year 2011 Estimates book, "*Construction and Environmental Compliance and Restoration (CECR) provides for design and execution of discrete and minor revitalization construction of facilities projects, facility demolition projects, and environmental compliance and restoration activities.*

The Construction of Facilities (CoF) program ensures that the facilities critical to achieving NASA's space and aeronautics programs are the right size and type, and that they are safe, secure, environmentally sound, and operated efficiently and effectively. It also ensures that NASA installations conform to requirements and initiatives for the protection of the environment and human health.

The purpose of NASA's Environmental Compliance and Restoration (ECR) program is to clean up chemicals released to the environment from past activities. Cleanups are prioritized by NASA to ensure that the highest priority liabilities are addressed first in order to protect human health and the environment and preserve natural resources for future missions."

NASA is requesting $397.3 million in FY 11 for Construction and Environmental Compliance and Restoration. Of that amount, about $335 million is for construction of facilities which provides for the construction, repair, rehabilitation, and modification of basic infrastructure and institutional facilities. Replacement and renewal projects replacing old, inefficient, and deteriorated buildings with energy efficient buildings will reduce utility usage. The remaining $62.1 million requested for FY 11 is for environmental compliance and restoration which provides the personnel, services, and activities necessary to complete the cleanup of hazardous materials and wastes that have been released to the surface or groundwater at NASA installations. These activities are mandated under a variety of Federal and state environmental laws and regulations, as well as legally enforceable orders and agreements.

NASA has recently undergone a comprehensive review of its facilities and is developing plans to reduce and renew these critical assets. It is worth noting that NASA's estimate of backlogged facilities and maintenance requirements totals about $2 billion. So while projected budget requests for construction and facilities rise from FY 12 ($316.3 million) to FY 15 ($349.0 million), it is unlikely that such projected levels will appreciably reduce the backlog in the near future. The Aerospace Safety Advisory Panel's 2009 Annual report identifies NASA's aging infrastructure as an important issue:

"*Over 80 percent of NASA facilities are beyond their design life, and annual maintenance is underfunded.] Facilities continue to degrade and facilities failures are starting to impact missions and have safety implications Agency-wide. Evidence for this can be seen in the increasing number of small fires, key equipment losses through failures in material handling and transportation facilities, and in the "weak signals" that we observe in current safety reports. The infrastructure used to launch complex vehicles into space must be reviewed and maintained down to the smallest component to remain safe. In the past, one of NASA's goals was 'ten healthy Centers.' A considerable investment in facility maintenance, repair, and replacement is needed for this goal to be achieved. This may be unrealistic in the current economic climate. Iffunding is not available, NASA should consider consolidating its programs and efforts at fewer Centers so that its activities may be safely continued at the remaining facilities. This planning needs to be part of a conscious and deliberate facilities strategy.*"

In the 2008 NASA Authorization Act (P.L. 110–422, Section 1022), the Congress had expressed concern over the need for adequate maintenance and upgrading of NASA's facilities In that legislation, the NASA Administrator was directed to determine and prioritize the maintenance and upgrade backlog at each of NASA's Centers and associated facilities and "*develop a strategy and budget plan to reduce that maintenance and upgrade backlog by 50% over the next five years.*" The Administrator is to deliver those reports to Congress concurrent with the delivery of the FY 11 budget request; the Committee has not yet received these reports.

Issues and questions related to Construction and Environmental Compliance and Restoration include the following:

- How long will it take NASA to reduce its maintenance and upgrade backlog? Does NASA have any plans to do so?
- Is the continued degradation of facilities impacting agency missions and the safety of these missions?
- Will NASA's proposed strategy for human exploration have any effect on its future environmental compliance and restoration responsibilities?

Other Issues

Economic Impact of NASA Activities

NASA's workforce and technology developments have a broad impact on the economy and society. NASA's past programs have developed technologies that are being used in the timing signals on an automatic teller, for credit card verifications at the gas station, and for providing tools that help navigate us through traffic. NASA's *Spinoffs 2009* report identifies several NASA-developed technologies that are spawning commercial products and services including:

- A NASA device that was developed to study cell growth in a simulated weightless environment that is used for medical research on treatments for heart disease and diabetes among other conditions;
- Scheduling software designed for the Hubble Space Telescope that is being used to help hospitals increase their efficiency in allocating capacity for imaging procedures; and
- Spacesuits with a sun-blocking fabric and cooling systems that are being modified for clothing to protect people with light sensitivities and people at the beach and who encounter sun exposure.

These products and services represent examples of how NASA-supported technologies and developments can be transitioned into products and services that contribute to a growing commercial space industry that is estimated at approximately $174 billion globally for 2008, according to *The Space Report 2009*.

In addition to stimulating commercial activity, NASA's challenging missions also lead to technological developments that make U.S. companies more competitive on a global basis and that enable companies to earn more work. At a Committee on Science and Technology hearing on the aerospace workforce and industrial base held in December 2009, one witness testified that "*It is no accident that the USA aerospace prime contractors and the hundreds of subcontractors have developed leadership positions on the vast majority of the relevant technologies. The NASA programs have clearly enabled USA companies to develop and maintain these leadership positions*." Some of the industrial base that NASA supports also serves U.S. national security programs.

NASA's scientific and technical jobs, like those of the broader aerospace industry, are highly skilled and well paid. NASA reports that it supports 45,000 work year equivalent contractors at or near its NASA centers. In addition, the Aerospace Industry Association, estimates that NASA indirectly supports 151,000 contractors. NASA also attracts the best and the brightest scientists and engineers. As one witness at the December 2009 Committee hearing on the aerospace workforce and industrial base who represented a NASA supplier company stated: "*NASA programs are really, really hard problems . . . . What that does is attract the very best and the very brightest engineers, and bright engineers attract other bright engineers*."

Attachment 1

NASA's FY 2011 Budget Request

Budget Authority ($M)	FY 2009	ARRA	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Science	4,503.0	400.0	4,493.3	5,005.6	5,248.6	5,509.6	5,709.8	5,184.0
Earth Science	1,377.3	325.0	1,420.7	1,801.8	1,944.5	2,089.5	2,216.6	2,282.2
Planetary Science	1,288.1	0.0	1,341.3	1,485.7	1,547.2	1,591.2	1,630.1	1,649.4
Astrophysics	1,229.9	75.0	1,103.9	1,076.3	1,109.3	1,149.1	1,158.7	1,131.6
Heliophysics	607.8	0.0	627.4	641.9	647.6	679.8	704.4	750.8
Aeronautics and Space Research and Technology	500.0	150.0	507.0	1,151.8	1,596.9	1,650.1	1,659.0	1,818.2
Aeronautics Research	500.0	150.0	507.0	579.6	584.7	590.4	595.1	600.3
Space Technology	0.0	0.0	0.0	572.2	1,012.2	1,059.7	1,063.9	1,217.9
Exploration	3,505.5	400.0	3,779.8	4,263.4	4,577.4	4,718.9	4,923.3	5,179.3
Exploration Research and Development	0.0	0.0	0.0	1,551.4	2,577.4	3,318.9	3,623.3	3,979.3
Commercial Spaceflight	0.0	0.0	0.0	812.0	1,400.0	1,400.0	1,300.0	1,300.0
Constellation Transition	0.0	0.0	0.0	1,900.0	600.0	0.0	0.0	0.0
Constellation Systems	3,033.2	400.0	3,325.8	0.0	0.0	0.0	0.0	0.0
Advanced Capabilities	472.3	0.0	454.0	0.0	0.0	0.0	0.0	0.0
Space Operations	5,764.7	0.0	6,180.6	4,887.8	4,290.2	4,253.3	4,362.6	4,130.5
Space Shuttle	2,979.5	0.0	3,139.4	989.1	86.1	0.0	0.0	0.0
International Space Station	2,060.2	0.0	2,317.0	2,779.8	2,983.6	3,129.4	3,221.9	3,182.8
Space and Flight Support (SFS)	725.0	0.0	724.2	1,119.0	1,220.6	1,123.9	1,140.7	947.7
Education	169.2	0.0	183.8	145.8	145.8	145.7	145.7	146.8
Cross-Agency Support	3,356.4	50.0	3,095.1	3,111.4	3,189.6	3,276.8	3,366.5	3,462.2
Center Management and Operations	2,024.3	0.0	2,067.0	2,270.2	2,347.4	2,427.7	2,509.7	2,594.3
Agency Management and Operations	921.2	0.0	941.7	841.2	842.2	849.1	856.8	867.9
Institutional Investments	293.7	50.0	23.4	0.0	0.0	0.0	0.0	0.0
Congressionally Directed Items	67.2	0.0	63.0	0.0	0.0	0.0	0.0	0.0
Construction and Evironmental Compliance and Restoration	0.0	0.0	448.3	397.3	363.8	366.9	393.5	398.5
Construction of Facilites	0.0	0.0	381.1	335.2	316.3	319.5	344.6	349.0
Environmental Compliance and Restoration	0.0	0.0	67.2	62.1	47.5	47.4	48.9	49.5
Inspector General	33.6	2.0	36.4	37.0	37.8	38.7	39.6	40.5
NASA FY 2010	17,782.4	1,002.0	18,724.3	19,000.0	19,450.0	19,960.0	20,600.0	20,990.0
Year to Year Change			5.30%	1.50%	2.40%	2.60%	3.20%	1.90%

Source: NASA

Attachment 2

Responsiveness to NASA Authorization Act of 2008

The NASA Authorization Act of 2008 [P.L. 110-422] authorized policy and appropriations for Fiscal Year 2009. The FY 2011 budget request appears to be responsive to the 2008 NASA Authorization Act in a number of areas, but diverges markedly from other areas of policy direction in the Act. Areas where the budget reflects direction and priorities established in the 2008 Act include: support for NASA's Earth Science Decadal Survey missions; support for aeronautics R&D on "green aviation"; support for extension of the operation and utilization of the International Space Station to at least 2020; and funding for exploration-related technology development activities. In addition, the request provides initial funding, in combination with funds requested for DOE, for restarting the domestic production of plutonium-238. The Administration's request for FY 2011 diverges from the 2008 Act in its proposed cancellation of the Constellation Program and in its investment in the development of commercial crew human spaceflight vehicles as the only potential direct U.S. access to the International Space Station, following the retirement of the Shuttle. The 2008 Act had made clear that the Congressional intent for a congressionally authorized commercial crew initiative "*not come at the expense of full funding of the amounts authorized...and for future fiscal years, for Orion Crew Exploration Vehicle development, Ares I Crew Launch Vehicle development, or International Space Station cargo delivery.*" In addition, while the FY 2011 request for NASA focuses heavily on advanced technology development, the request does not propose funding for advanced technology development within the Science Mission Directorate, as directed in the 2008 Act.

Chairman GORDON. Come to order. We have got some interest in this hearing from members off the committee, and as long as space allows for it, I would like to include them on the dais.

I remind folks that non-committee members are only recognized for questions after all committee members have been recognized. So without objection, Mr. Posey, Mr. Bishop, and Dr. Griffith would be allowed to participate if they so choose, and we welcome them here. Mr. Posey is—or rather Mr. Bishop is an alumnus of this committee, so we welcome you back.

We are also—if you are—we all know that Ralph Hall is in a time machine anyway. He doesn't get any older, but if you think he has reversed, he hasn't. He couldn't be here today, and we are glad that Mr. Olson could take his place as the Ranking Member on the Space and Aeronautics Subcommittee. He is certainly well qualified to handle these chores today.

So good morning and welcome Administrator Bolden. Today's hearing marks the beginning of this committee's review of NASA's fiscal year 2011 budget request, including the proposed changes to the Nation's human spaceflight plans.

As you know NASA is an agency that occupies an important place in the Nation's R&D infrastructure, as well a being a source of inspiration and pride for all of our citizens. I know that my colleagues on both sides of the aisle want to make sure that we do all we can to ensure its future health and productivity.

In that regard I am pleased that the President's fiscal year 2011 NASA budget request has a number of positive features. First, of course, is the fact that the budget request will increase NASA's five-year funding by a total of $6 billion over last year's out-year funding plan. It is less than many supporters of NASA believe is justified or needed, but in a fiscal environment in which many Federal agencies and programs are facing a funding squeeze, it represents a vote of confidence in NASA, and that should not be ignored.

There are other good things in the proposed NASA budget. It recognizes the critical role of NASA's Earth Science Program and Climate Research play in increasing our understanding of climate change and other phenomena that impact our society. It moves to restore some of the purchasing power that was lost by NASA's Earth Science Program over the past decade.

Aeronautics is another area that gets a needed boost in the fiscal year 2011 NASA budget request. It is hard to think of another NASA program that has had more of an impact on our economic competitiveness, national security, and quality of life, and I am pleased that its importance is recognized in this budget proposal.

In addition, the budget recognizes the importance in investing in long-term technology development for both aeronautics and space, a view long shared by this committee.

And finally, this budget also makes provisions for extending the operation of the International Space Station beyond 2015, as well as providing funds to allow for an orderly completion of the Space Shuttle's flight manifest; two very constructive steps.

All of these initiatives that I have described are ones that I think could garner bipartisan support on this committee and the House

at large. They are certainly consistent with last year's NASA Authorization Act.

However, there are other features of this request that haven't gained much support. Namely, this budget proposal represents a radical change from the approach to human spaceflight and exploration that has been authorized and funded by the successive Congresses over the past five years. This new approach is not clearly traceable to either past legislation or past policy directives. It has raised as many questions as it has answered.

Administrator Bolden, as you know, many folks in your own agency do not appear to have known what was in the budget request until the very weekend before its release. In addition, it has taken almost a month for Congress to get NASA's budget justification documents, a state of affairs that is not and should not be an acceptable way of doing business with regards to such an important national endeavor.

This hearing is intended to help us understand the rationale for such a substantial change in direction from the approach of previous authorizations. In that regard, Administrator Bolden, there are a number of questions that I hope you will be able to address.

For example, a feature of this proposal and one that has not garnered much support on the Hill is a plan to rely on as yet to be developed commercial crew transportation systems with no government back-up system. Leaving aside the issue of safety for the moment, do you have concrete evidence that you can provide us that shows that there will be sufficient, non-NASA commercial crew transportation markets to keep these companies viable, or is NASA going to be on the hook to do whatever it takes to keep them in business since NASA will have no other means of getting into orbit.

That is, will NASA's action make these companies too important to fail despite the lack of any significant existing markets for their proposed services; with all the implications from the American taxpayer inherent in that phrase?

In addition, in this budget request you are requesting a 62 percent increase over what the government and the companies have previously said would be needed to help the two would-be commercial cargo transportation companies develop their systems; systems that are arguably much less challenging than the commercial crew transportation system that you would now want to support. Given the large cost increase, how much confidence should we have in the cost estimates for commercial crew contained in this budget request?

I could go on to ask about other aspects of the human spaceflight proposal, but I have already taken enough time, enough of the committee's time. It is clear that the administration's human spaceflight proposals have profound implications for the workforce, for our position in the world, and for the future of the space program, and we are going to take a hard look at them.

[The prepared statement of Mr. Gordon follows:]

PREPARED STATEMENT OF CHAIRMAN BART GORDON

Good morning, and welcome, Administrator Bolden. Today's hearing marks the beginning of this Committee's review of NASA's Fiscal Year 2011 budget request, including the proposed changes to the nation's human space flight plans. As you know, NASA is an agency that occupies an important place in the nation's R&D in-

frastructure, as well as being a source of inspiration and pride for all of our citizens. I know that my colleagues on both sides of the aisle want to make sure that we do all we can to ensure its future health and productivity. hi that regard, I am pleased that the president's FY 2011 NASA budget request has a number of positive features.

First, of course, is the fact that the budget request would increase NASA's five-year funding by a total of $6 billion over last year's outyear funding plan. It is less than many supporters of NASA believe is justified or needed, but in a fiscal environment in which many Federal agencies and programs are facing funding freezes, it represents a vote of confidence in NASA that should not be ignored.

There are other good things in the proposed NASA budget. It recognizes the critical role that NASA's Earth science program and climate research play in increasing our understanding of climate change and other phenomena that impact our society, and it moves to restore some of the purchasing power that was lost by NASA's Earth science program over the past decade.

Aeronautics is another area that gets a needed boost in the FY 2011 NASA budget request. It is hard to think of another NASA program that has had more of an impact on our economic competitiveness, national security, and quality of life, and I am pleased that its importance is recognized in this budget proposal. In addition, the budget recognizes the importance in investing in long-term technology development for both aeronautics and space, a view long shared by this Committee.

Finally, this budget also makes provision for extending the operations of the International Space Station beyond 2015, as well as providing funds to allow for an orderly completion of the Space Shuttle's flight manifest—two very constructive steps.

All of the initiatives that I have described are ones that I think could garner bipartisan support on this Committee and in the House at large—they are certainly consistent with last year's NASA Authorization Act.

However, there are other features of this request that haven't gained much support. Namely, this budget proposal represents a radical change from the approach to human space flight and exploration that has been authorized and funded by successive congresses over the past five years. This new approach is not clearly traceable to either past legislation or past policy directives, and it has raised as many questions as it has answered. Administrator Bolden, as you know, many folks in your own agency do not appear to have known what was in the budget request until the very weekend before it was released.

In addition, it has taken almost a month for Congress to get the NASA budget justification documents, a state of affairs that is not—and should not be—an acceptable way of doing business with regard to such an important national endeavor. This hearing is intended to help us understand the rationale for such a substantial change in direction from the approach of previous authorizations. In that regard, Administrator Bolden, there are a number of questions that I hope you will be able to address. For example, a feature of this proposal, and one that has not generated much support on the Hill, is the plan to rely on as-yet-to-be-developed commercial crew transport systems with no government backup system.

Leaving aside issues of safety for the moment, do you have concrete evidence that you can provide us that shows that there will be sufficient non-NASA commercial crew transport markets to keep these companies viable, or is NASA going to be on the hook to do whatever it takes to keep them in business since NASA will have no other means of getting into orbit? That is, will NASA's actions make these companies "too important to fail" despite the lack of any significant existing markets for their proposed services-with all of the implications for the American taxpayer inherent in that phrase?

In addition, in this budget request you are requesting a 62% increase over what the government and the companies had previously said would be needed to help the two would-be commercial cargo transport companies develop their systems—systems that are arguably much less challenging than the commercial crew transport systems you now want to support. Given that large cost increase, how much confidence should we have in the cost estimates for commercial crew contained in this budget request? I could go on to ask about other aspects of the human space flight proposals, but I've already taken up enough of the Committee's time.

It is clear that the Administration's human space flight proposals have profound implications for the workforce, for our position in the world, and for the future of our space program, and we are going to take a hard look at them. Administrator Bolden, you have a tough job. And I know that you are doing your best to be an advocate for this budget request and to present it in the best light that you can. However, I must be frank. So far, this plan has not found a lot of support here on the Hill. That could change, of course, but at present I cannot be confident that the

votes are there to enact this budget proposal as is, and you shouldn't be either. So I'm going to ask you to be flexible and open, as changes may be required to this plan if we are to achieve a durable consensus here in Congress.

Again, I want to welcome you to today's hearing, and I now yield to my good friend, Ranking Member Hall.

Mr. GORDON. Again, I want to welcome you to today's hearing, and now I want to yield to another Texan, Mr. Olson.

Mr. OLSON. Thank you very much, Mr. Chairman, and first of all I want to make a very public statement that I realize that I am a poor substitute for the wit and wisdom of our Ranking Member, Ralph Hall, but he couldn't be here today, and he asked that I read his opening statement, and with your permission, Mr. Chairman, I would like to do so.

Mr. Chairman, I look forward to working with you on the important issues facing NASA, and thank you for holding today's hearing on the fiscal year 2011 budget proposal. Thanks to your leadership today is benefit—NASA is benefiting from the guidance provided in the *NASA Authorization Act of 2008*.

I also want to welcome the NASA Administrator, General Bolden, to his first appearance before our committee. We look forward to hearing the details of the administration's proposals.

NASA's fiscal year 2011 proposal is a radical departure from the consensus that emerged after the *Columbia* accident. In fact, the NASA debate after the accident helped clarify many of the guiding principles and goals that were endorsed by both Republicans and Democrats in subsequent NASA authorizations.

The Columbia Accident Investigation Board clearly warned us about the inherent risk of human spaceflight program that does not have vigorous and engaged national leadership. The CAIB also stressed the importance of working towards established goals, not flexible paths, and warned against unbounded technology development programs that lacking clear requirements in metrics are likely to fall prey to future budget reductions.

As a mission-driven organization, NASA performs best with clear goals and destinations. I am deeply troubled about the future viability of America's human spaceflight. On the eve of completing the International Space Station and retiring the Space Shuttle, I cannot understand how the administration can propose such an ill-conceived decision to cancel the Constellation Program without providing a compelling alternative plan with measurable goals and adequate resources.

This budget proposal, relying as heavily as it does on the unproven capabilities of a nascent commercial space industry, contains very few details. At worst, I am afraid that its reliance on the commercial, its reliance on commercial is unfounded, and as a consequence it not only threatens our leadership in space and our utilization of the International Space Station, but it also risks the loss of much of our aerospace industrial base and our highly-skilled workforce.

I am also bothered by the apparent diminishment of crew safety in this request. Except for vague assurances that safety will not be undermined, I see no detail explaining how NASA plans to ensure that commercial systems will be equal to the expectations that guided the development of the Constellation.

Until we in Congress have had a chance to examine the details of NASA's proposal and develop the appropriate legislation, I hope you will adhere to the intent of the appropriators, which is to continue the Constellation development in fiscal year 2010.

General Bolden, I appreciate the fact that you accept responsibility for the poor way this budget was publicly rolled out, and I want you to take a message back to those who played an active role in its unveiling that such an exercise is ultimately counterproductive. This committee has been the most ardent supporter of NASA in the House, yet senior agency and administration officials have managed to surprise, frustrate, and anger those of us who have been your greatest advocates.

I thought it was particularly troubling that senior people within the administration and on your staff engaged in a campaign of telephone calls with reporters prior to the budget rollout to explain embargoed program details instead of providing briefings to this committee. This is not a media campaign. NASA should be communicating with its policy and oversight committees, and I encourage you to carry that message back to the administration's suite and to the administration.

Mr. Chairman, I care deeply about NASA, and I want to ensure the safety of the crews we send into space. I want to ensure that we can maintain and utilize the International Space Station. I want NASA to have clearly-defined goals because I believe that that is the only way we will make any progress. NASA is a mission-driven organization that produces its best results with clearly-defined goals and the resources to achieve them.

I believe NASA's priorities are misplaced. With the retirement of the Space Shuttle and a plan to cancel the Constellation Program, it is more important than ever that we work together to provide NASA with the legislative guidance it needs. I know you share many of my concerns.

I look forward to close—working close with you, and I hope you will make room in our busy schedule to hold the necessary hearings to ensure we give NASA the guidance it needs.

Yield back my time.

[The prepared statement of Mr. Olson follows:]

PREPARED STATEMENT OF REPRESENTATIVE PETE OLSON

Mr. Chairman, I look forward to working with you on the important issues facing NASA and I thank you for holding today's hearing on their fiscal year 2011 budget proposal. Thanks to your leadership, NASA today is benefiting from the guidance provided in the *NASA Authorization Act of 2008*.

I also want to welcome the NASA Administrator, General Bolden to his first appearance before our Committee. We look forward to hearing the details of the Administration's proposals.

NASA's fiscal year 2011 proposal is a radical departure from the consensus that emerged after the Columbia accident. In fact, the national debate after the accident helped to clarify many of the guiding principles and goals that were endorsed by both Republicans and Democrats in the subsequent NASA Authorizations. The Columbia Accident Investigation Board clearly warned us about the inherent risks of a human space flight program that does not have vigorous and engaged national leadership. The CAIB also stressed the importance of working toward established goals, not flexible paths, and warned against unbounded technology development programs that, lacking clear requirements and metrics, are likely to fall prey to future budget reductions. As a mission-driven organization NASA performs best with clear goals—and destinations.

I am deeply troubled about the future viability of America's human space flight program. On the eve of completing the International Space Station and retiring the Space Shuttle, I cannot understand how the Administration can propose such an ill-conceived decision to cancel the Constellation program without providing a compelling alternative plan with measurable goals and adequate resources. This budget proposal, relying as heavily as it does on the unproven capabilities of a nascent commercial space industry, contains very few details. At worst, I am afraid that its reliance on commercial is unfounded, and as a consequence, it not only threatens our leadership in space and our utilization of the International Space Station, but it also risks the loss of much of our aerospace industrial base and our highly-skilled workforce.

I am also bothered by the apparent diminution of crew safety in this request. Except for vague assurances that safety will not be undermined, I see no detail explaining how NASA plans to ensure that commercial systems will be equal to the expectations that guided the development of Constellation.

Until we in the Congress have had a chance to examine the details of NASA's proposal and develop the appropriate legislation, I hope you will adhere to the intent of the Appropriators which is to continue with the Constellation development in FY 2010.

General Bolden, I appreciate the fact that you accept responsibility for the poor way this budget was publicly rolled out, and I want you to take a message back to those who played an active role in its unveiling that such an exercise is ultimately counter-productive. This committee has been the most ardent supporter of NASA in the House, and yet senior agency and Administration officials have managed to surprise, frustrate and anger those of us who have been your greatest advocates. I thought it particularly troubling that senior people within the Administration and on your staff engaged in a campaign of telephone calls with reporters prior to the budget rollout to explain embargoed program details instead of providing briefings to this Committee. This is not a media campaign. NASA should be communicating with its policy and oversight committees. I encourage you to carry that message back to the Administrator's suite and to the Administration.

Mr. Chairman, I care deeply about NASA, and I want to ensure the safety of the crews we send into space. I want to ensure we can maintain and utilize the International Space Station. I want NASA to have clearly defined goals because I believe that is the only way we will make any progress. NASA is a mission-driven organization that produces its best results with clearly defined goals and the resources to achieve them. I believe NASA's priorities are misplaced. With the retirement of the Space Shuttle and a plan to cancel the Constellation program, it is more important than ever that we work together to provide NASA with the legislative guidance it needs. I know you share many of my concerns. I look forward to working closely with you and I hope you will make room in our busy schedule to hold the necessary hearings to ensure we give NASA the guidance it needs.

Chairman GORDON. Thank you, Mr. Olson.

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

[The prepared statement of Ms. Giffords follows:]

PREPARED STATEMENT OF REPRESENTATIVE GABRIELLE GIFFORDS

Good morning. I would like to join Chairman Gordon in welcoming NASA Administrator Bolden to today's hearing. He is an inspiring individual, and as an astronaut himself, I know that he cares greatly for the space program and the future of human space flight.

Today's hearing is one of the most important we will hold this year, as it bears directly on the future of our nation's space program. It will inform us on many key issues facing NASA, and we will be weighing many options in the subcommittee on space and aeronautics, on which I serve as chair, as we write reauthorization legislation for NASA.

There is no doubt that NASA and our space program help define America in the eyes of the rest of the world. Not quite fifty years ago President Kennedy announced that America would land a man on the moon and return him safely to Earth. We committed the best and brightest of a generation to this goal and through the combined efforts of the newly formed National Aeronautics and Space Administration and the ever innovative commercial aerospace industry, we accomplished that goal in a short eight years. It is no exaggeration to say that we took the world to the

moon; the landing was watched by 500 million people worldwide. Out of the initial competition that spurred the space race came unprecedented international collaboration and was born an America that was the unequivocal world leader in aeronautics. This is a legacy we should never abandon.

Our space program has always been an engine of innovation for our nation, and equally importantly, a source of inspiration. When the Space Shuttle, the icon of the American space program, first flew in the early 80s you would be hard pressed to find a child who did not want to grow up to be an astronaut, and that meant staying in school, working hard, and taking math and science classes seriously. The space program has always inspired the youth of America to reach for the stars. As Members of Congress, and as Americans, we must refuse to let that dream fade.

Today we discuss the President's proposals for the future of NASA. Chairman Gordon has highlighted a number of the proposals positive features, and I wish to state my agreement with him. There is good news for NASA in the president's budget request for NASA. The boost to science funding is in agreement with this committee and the president's repeatedly stated commitment to American investment in the sciences. The new investment in aeronautics research is also welcome and probably long overdue and will be critical to our future exploration.

However, there are also features of the FY 2011 budget request that concern me greatly. As I stated in our subcommittee hearing earlier this month, I have serious concerns about the impact of this budget proposal on the future of American human space flight and exploration. By canceling the program of record, we trade a program that we know will work—even though it faced inevitable delays in part due to insufficient funding—that we know will safely take our astronauts, our American heroes, to space for a program that may work, but is in all honesty poorly defined.

What is most striking about the budget is the lack of an overall vision. We went to the moon with a vision of exploring our first heavenly body; we flew the shuttle and International Space Station with the vision of living continuously in space. What is our vision now? What Congress and the American people deserve is a detailed plan: *Where* are we going? *How* will we get there? And *when* will we go?

Today in your testimony you mentioned Mars as the ultimate destination, with a slew of other potential targets along the way. But how will we get out of low-earth orbit when we have no plans to build a heavy life vehicle? If the intention is to pause our development of an HLV for a few years while we develop new technologies, or to skip an HLV for a plan of multiple launches with in-orbit refueling and assembly, then I would like to see a plan and timetable for how and when we would have these things operational and then how they would take us to our destinations. If our plan is to go to the moon or asteroids of Lagrange points before setting off for Mars—each of these requiring significantly different systems—then I want to see a plan to do that.

It is simply unfair to ask the American people to hand over billions of dollars for something that isn't even detailed enough to qualify for a loan from a loan shark.

With that said, I am encouraged by the COTS program. As you mentioned in your testimony, we are hopefully close to seeing a test flight of the SpaceX Falcon rocket. I hope that is successful and that they quickly proceed to their goal of delivering cargo to ISS. Should this program succeed it gives us great hope that commercial crew—which is of course much more difficult and risks the lives of American heroes—could succeed. I believe that this committee and the Congress as a whole would be delighted to see this industry grow, and it would free up NASA to focus solely on missions beyond low Earth orbit, as envisioned in our previous NASA Authorization. Therefore, I am happy to see the president commit to making this a reality. However, I have *strong* reservations about pursuing this *at the expense* of the program that would take us out of LEO. That simply doesn't make sense. Congress intended to turn over LEO to commercial taxi services when they were proven, but what's the point if NASA hasn't developed the capability of flying at all?

There are also many unresolved questions regarding commercial crew services. Who will handle things like mission control and capsule retrieval? How will indemnity be handled? Will companies big and small be able to compete for these contracts or will they be limited by the size of their liability?

Additionally, I am concerned, as are most of my colleagues here, that outright cancellation of the entire Constellation program would put tens of thousands of engineers out of work and risk the vitality of the manufacturing base. Perhaps when commercial crew services are established there will be a robust industry that can absorb all these workers, but at this time I just don't see where they will go. These are exactly the types of good jobs we're trying to create. I think in this case it's a lot easier to save a job than to create a new one. In addition, these are exactly the type of jobs we need to keep here in America to shore up our innovation economy and protect our manufacturing base. I would hate to see American aeronautical en-

gineers emigrating to Europe, India, Russia, and China because that's where the action is.

My concern when considering the space program is not one pet project versus another; one aerospace company versus another; or one administration's plan versus another's. My concern is the prudent use of taxpayers' money, which cannot be accomplished by switching course every few years. The unknown unexplored path will also seem more exciting and more promising than the program of record, and in the spirit of discovery we should explore it, but not at the cost of a sure fire bet.

My concern is the stewardship of a skilled American workforce and maintaining a manufacturing base that is second to none. Not just saving but *creating* jobs in a sector that will create a demand for scientists and engineers. I believe that the best and brightest young minds in our nation are smart enough to understand supply and demand, and so one understands why a sufficiently bright young student would eschew the vagaries and uncertainty of the aerospace industry for a more lucrative career in finance or law.

Finally, my concern is maintaining the American dream to reach for the stars and honoring our legacy that America will continue to lead the world into the heavens, exploring the great unknown.

The future of U.S. leadership in space is at stake, and we need to make hard decisions. Luckily presidents and members Congress from both sides of the aisle have long found common ground and common cause in our nation's reach for the stars—a fact worth noting in the hyper partisan era in which we find ourselves in today. For nearly two generations, Republicans and Democrats alike have agreed that exploring the universe is not only worthwhile, but necessary. That past should guide us as we chart NASA's future. Today's hearing will help us get the information we will need to make the informed decisions necessary.

We continue to be that city upon a hill, and the world at this very moment watches us. Our space program is one of the crown jewels of our nation, and we must proceed carefully to maintain it.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good Morning. Thank you, Mr. Chairman, for holding today's hearing on the National Aeronautics and Space Administration's (NASA) Fiscal Year 2011 (FY 11) budget request.

The President's budget calls for $19 billion in FY 11 for NASA, which is a $270 million increase from FY 2010. I am pleased to see that the FY 11 budget request continues to address the budget shortfalls NASA saw during the previous administration. However, the budget is a general departure from the NASA Authorization Act of 2008 passed by Congress and signed into law and represents several important changes in the mission and focus of NASA. Most importantly, the budget terminates the Constellation program, in which the government has invested $9 billion over the last four years. Constellation represented NASA's sole program to bring humans to the International Space Station and the Moon, and its termination raises significant questions about the future mission and direction of human spaceflight in the U.S.

First, the end of Constellation will result in the loss of tens of thousands of jobs at NASA and the companies with whom NASA has contracted out work. With the budget's strong investment in commercial human spaceflight over government-operated programs, there is a chance these jobs could disappear all together. I would like to hear from Administrator Bolden what plans are in place to assist in the transition of this workforce.

Second, with the end of Constellation, a return to the moon by 2020 will no longer be NASA's central goal in human spaceflight and exploration. In place of this definite mission, the FY 11 budget invests in three broad technology development programs and does not clearly indicate what NASA's next destination will be or provide a clear outline of how NASA's mission will change with the end of the Space Shuttle and the elimination of Constellation. I am interested in hearing more about the destinations, timelines, and metrics that will make up NASA's missions in view of these changes and how the vehicles and technological improvements developed for the new research programs will guide this new mission.

Third, investing in Science, Technology, Engineering, and Mathematics (STEM) education programs is necessary to ensure the next generation of our aerospace workforce is competitive. For this reason, I am concerned about the $38 million reduction in funding for NASA's STEM programs. While the decrease is concerning, I support the President's proposals to improve NASA's outreach to young students

through the Summer of Innovation program and the Explorer Schools pilot program, which will play an important role in inspiring young students to pursue careers in STEM fields. However, with no clear mission or destination, young students may not be inspired to pursue careers at NASA or in aerospace. I would be interested to know how NASA plans to continue attracting a strong workforce in view of decreased funding and elimination of NASA's mission.

Finally, as the Chairman of the Aviation Subcommittee, I am pleased to see that NASA will increase its investment in aeronautics research by $73 million. This investment will be particularly important for the Next Generation Air Transportation System (NextGen), and its important work to modernize our national air transportation system. However, this increased funding will not fully replace the $143 million decrease NextGen saw FY 10. Continuing to increase NextGen funding will ensure that NASA continues to contribute vital research on aviation safety and environmental impacts of air travel. I would like to hear from Administrator Bolden how this year's funding levels will impact NASA's role in implementing NextGen.

I welcome Administrator Bolden, and I look forward to his testimony. Thank you again, Mr. Chairman.

[The prepared statement of Mr. Grayson follows:]

PREPARED STATEMENT OF REPRESENTATIVE ALAN GRAYSON

Mr. Bolden, thank you for your leadership as the NASA Administrator, since your swearing in on the symbolic date of July 17th, the same week as our nation's 40th anniversary of the celebrated Apollo 11th lunar landing. As a member of the Florida delegation, the House Science & Technology Subcommittee on Space & Aeronautics, and an outspoken advocate of space exploration, I look forward to working closely with you as we face both the challenges and triumphs that will lead the United States space program into the future.

There were many features of the President's NASA budget that I support: an overall increase of $6 billion in NASA funding over the next five years, the extension of the International Space Station beyond 2015, an elevated focus in NASA's earth science and climate research, and overall funding increases in the aeronautics program. I applaud these aspects of the President's NASA budget, and appreciate the Administration's commitment to science and the advancement of technology.

However, that being said, I cannot hide my utter disappointment and disapproval of the basic lack of vision reflected in this budget. Mr. Bolden, with these proposed changes in U.S. space policy, and no clear mission directorate for NASA's space exploration program, NASA's future in space is headed for nowhere. At a time when our international competitors are gaining, now is not the appropriate time for NASA to shed its leadership role in space exploration. On May 7, 2009, the Office of Science and Technology Policy announced the formation of the "Review of United States Human Space Flight Plans Committee", also known as the Augustine Committee. This Committee was formed with the primary goal of ensuring that our great nation is on "a vigorous and sustainable path to achieving its boldest aspirations in space", and put together a number of options in which U.S. space exploration could move forward. The Administration chose none of them. Instead it declared a space policy based upon wishful thinking, and provided a budget that will take a once storied and inspiring agency and will outsource its services to an unproven private sector.

Mr. Bolden, the absence of a plan, is not a plan. The magic of the marketplace will not save our space exploration program, and it will certainly not provide the inspiration and pride that American's knew in 1969. As a Member of Congress, and a space enthusiast, I ask the Administration to scrap this short sighted proposal, so that we may work together in reestablishing ourselves as the worldwide leader in space exploration.

At this time I would like to introduce our only witness today, Mr. Charles Bolden, who is the Administrator of the National Aeronautics and Space Administration. Welcome, Mr. Bolden. As our witnesses or witness should know, any additional statement other than your written statement or spoken statement will be made a part of the record, and with that we will then follow with questions from our members for—at five minutes.

So, Mr. Bolden, you are—you may proceed.

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

Mr. BOLDEN. Mr. Chairman and Members of the Committee, thank you very much for the opportunity to discuss the President's 2011 budget request for NASA. I am grateful for the support and guidance of this committee, and I look forward to working with you on enactment of the President's bold new direction for our agency.

I want to say upfront that I understand the committee's concerns that details such as our justification documents have been slow to reach you. I apologize and ask your continued patience as we finalize the details of this historic change in NASA's direction.

Since the introduction of the budget, many have asked what the destination is for human spaceflight beyond low-earth orbit under the President's plan. NASA's exploration efforts will focus not just on our moon but also on near-earth asteroids, strategic deep space zones called Lagrange points, and the planet Mars and its moons. For me the ultimate destination in our solar system at present is Mars.

While I—we cannot provide a date certain for the first human visit, with Mars as a key long-term destination we can identify missing capabilities needed for such a mission and use this to help define many of the goals for our emerging technology development. The right investments in technology will allow us to map out a realistic path to this destination that continues to inspire generations of school children, just as it inspired me years ago growing up in Columbia, South Carolina, and watching Buck Rogers go to Mars with ease each week from my seat in the balcony of the Carolina Theatre in Columbia.

The President's fiscal year 2011 budget request for NASA is $19 billion, including an increase of $276 million over the enacted 2010 level. Longer term, I am pleased that the budget commits an increased investment of $6 billion to—in NASA's science, aeronautics, and enabling technologies over the next five years compared with last year's plan.

All of us at NASA appreciate the President making NASA such a high priority at a time when the budget realities dictate reductions and freezes for other worthwhile programs. With the President's new vision, the NASA budget will invest much more heavily on technology R&D than recent NASA budgets. This will foster new technological approaches, standards, and capabilities that are critical to enable next generation spaceflight, Earth sensing, and aeronautics capabilities.

These investments will produce additional opportunities for U.S. industry and spur new businesses such as a recently-announced partnership between NASA and General Motors to build an advanced dexterous humanoid robot we call R2. I want to share a few highlights about NASA's bold new path to become an engine of innovation with an ambitious new space program that includes and inspires people around the world.

Under this program the United States will pursue a more sustainable and affordable approach to human space exploration through the development of transformative technologies and systems. We will encourage the development of commercial human spaceflight vehicles to access low Earth orbit. We will develop new

technologies that will enable more efficient U.S. human exploration into the solar system than is currently conceived.

As the Constellation Program is ended in an orderly manner, I want to thank all of the NASA employees and contractors who have worked so hard on that program. Their commitment has brought great value to the agency and to our Nation, and they will continue to play a pivotal role in NASA's future path.

Many of the things NASA has learned from the Constellation Program will be critical as the agency moves forward. More specifically, in fiscal year 2011, NASA will undertake a flagship technology development and demonstration program with our international partners, commercial and other government entities, to demonstrate critical technologies such as in-orbit propellant storage and transfer, inflatable modules, autonomous automated rendezvous and docking, and closed-loop life support systems.

Heavy-lift research and development that will investigate a broad scope of R&D activities to support new space vehicle propulsion technologies, robotic precursor missions to multiple destinations in the solar system in support of future human exploration, including missions to Mars, the moon, Mars and its moons, Lagrange points, and nearby asteroids.

Significant investments for the development of commercial crew and further cargo capabilities, extension of the lifetime of the International Space Station to 2020, or beyond, in concert with our international partners. Pursuit of cross-cutting space technology capabilities led by the newly-established office of the chief technologist to spawn game-changing innovations to make space travel more affordable and more sustainable.

Climate change and observations which will enable NASA to substantially accelerate and expand its earth science capabilities, including a replacement for the Orbiting Carbon Observatory. Aeronautics R&D including critical areas of Next Generation Air Transportation System or NextGen, green aviation and safe integration of unmanned aircraft systems into national airspace. Education initiatives, including the recently announced Summer of Innovation pilot program, to inspire middle school students.

Americans and people worldwide have turned to NASA for inspiration throughout our history. Our work gives people an opportunity to imagine what is barely possible, and we at NASA get to turn those dreams into real achievements for all mankind through the missions we execute.

This budget gives NASA a roadmap to even more historic achievements as it spurs innovation, employs Americans in exciting jobs, and engages people around the world.

Mr. Chairman, thank you again for your support and that of this committee. I would be pleased to respond to any questions you or other Members of the Committee may have.

[The prepared statement of Mr. Bolden follows:]

PREPARED STATEMENT OF CHARLES F. BOLDEN, JR.

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear today to discuss the President's FY 2011 budget request for NASA. NASA is grateful for the support and guidance received from this Committee through the years and looks forward to working with you on enactment of the President's bold new direction.

The President's FY 2011 budget request for NASA is $19.0 billion, which represents an increase of $276.0 million above the amount provided for the Agency in the FY 2010 Consolidated Appropriations Act (P.L. 111–117), and an increased investment of $6.0 billion in NASA science, aeronautics, human spaceflight and enabling space technologies over the next five-years compared with last year's budget plan. Enclosure 1 displays the details of the President's FY 2011 budget request for NASA.

Before I discuss the details of the NASA budget request, I would like to talk in general about the President's new course for human exploration of space. Our mission is to develop the required technology, knowledge and infrastructure to sustainably extend human presence throughout the solar system. NASA's exploration efforts will focus not just on our moon, but also on near-earth asteroids, strategic deep space zones called Lagrange points, and the planet Mars and its moons. For me, the ultimate destination in our solar system at present is Mars. While we cannot provide a date certain for the first human visit, with Mars as a key long-term destination we can identify missing capabilities needed for such a mission and use this to help define many of the goals for our emerging technology development.

Let me pause here for a moment to emphasize that we need the new capabilities and knowledge we are developing, not to perfect our approach to spaceflight, but to enable even the most basic of missions. For example, if you gave NASA unlimited resources today, we could not take a human safely to Mars in the near future, because we have not solved the interrelated problems of shielding humans from radiation in space, providing consumables to last the distance, and constructing a rocket to take all of those items into space.

Over the next several years, NASA will build technologies and infrastructure to enable safe human exploration at a more sustainable rate. If done properly, the United States and its partners will be able to send human missions beyond low earth orbit more safely, more-cost-effectively, and more capably than currently conceived.

First, we will extend the life of the International Space Station (ISS), likely to 2020 or beyond. The unique laboratory environment of the ISS will provide answers to key questions about human survivability in space and provide the environment to test critical enabling technologies to benefit life on Earth as well as enhance our ability to venture to destinations such as Mars, the Moon, and asteroids.

We will also encourage and support private sector investment in space. NASA has already invested in the private sector to transport cargo to the ISS. Two companies are making great progress, and we hope in the next few months to have the first demonstration of the Falcon 9 that will serve as the launch vehicle for the SpaceX system. The FY 2011 budget also includes a $6 billion, five-year investment in *crew* transport to the ISS by a broad range of private companies. When successful this will expand the utilization of not only the ISS but also near Earth space to a greater segment of society.

Several years from now, when we have developed some of the critical technologies we need to explore safely and effectively, when our robotic precursor missions have scouted out the most interesting sites for human exploration, when our international partners have worked with us to develop new exploration architectures with shared costs and benefits, then we will be ready to press the accelerator for human missions into the solar system. Our goal will be then, as it is now, to create a lasting human space-faring capability for our nation, and with our international and commercial partners, for the World. Now let me turn to describe the FY 2011 NASA budget request in detail.

Highlights of the FY 2011 Budget Request

The President has laid out a bold new path for NASA to become an engine of innovation, with an ambitious new space program that includes and inspires people around the world. Beginning in FY 2011, the United States will pursue a more sustainable and affordable approach to human space exploration through the development of transformative technologies and systems. As the Constellation Program is ended in an orderly manner, NASA will encourage the development of commercial human spaceflight vehicles to safely access low-Earth orbit and will develop new technologies that will lay the foundation for a more exciting, efficient and robust U.S. human exploration of the solar system than we are currently capable of, while further strengthening the skills of our workforce and our Nation in challenging technology areas. NASA will also invest increased resources in climate change research and observations; aeronautics research and development (R&D), including green aviation; space technology development of benefit across the entire space sector; and education with an emphasis on Science, Technology, Engineering and Mathematics (STEM) learning.

Here is a broad outline of the FY 2011 budget plan followed by more details. In FY 2011, NASA will undertake:

- Transformative technology development and demonstrations to pursue new approaches to human spaceflight exploration with more sustainable and advanced capabilities that will allow Americans to explore the Moon, Mars and other destinations. This effort will include a flagship demonstration program, with international partners, commercial and other government entities, to demonstrate critical technologies, such as in-orbit propellant transfer and storage, inflatable modules, automated/autonomous rendezvous and docking, closed-loop life support systems, and other next-generation capabilities. It will also include projects that are smaller and shorter-duration, which will demonstrate a broad range of key technologies, including *in-situ* resource utilization and advanced in-space propulsion.
- Heavy-lift propulsion research and development that will investigate a broad scope of R&D activities to support next-generation space launch propulsion technologies, with the aim of reducing costs and shortening development timeframes for future heavy-lift systems for human exploration.
- Robotic precursor missions to multiple destinations in the solar system in support of future human exploration, including missions to the Moon, Mars and its moons, Lagrange points, and nearby asteroids.
- Significant investments for the development of commercial crew and further cargo capabilities, building on the successful progress in the development of commercial cargo capabilities to-date. NASA will allocate these funds through competitive solicitations that support a range of higher- and lower-programmatic risk systems and system components, such as human-rating of existing launch vehicles and development of new spacecraft that can ride on multiple launch vehicles.
- Extension of the lifetime of the International Space Station (ISS), likely to 2020 or beyond, in concert with our international partners, with investments in expanded ISS utilization through upgrades to both ground support and onboard systems and use of the ISS as a National Laboratory.
- Pursuit of cross-cutting Space Technology capabilities, led by the newly established Office of the Chief Technologist, which will fund advancements in next-generation technologies, to help improve the Nation's leadership in key research areas, enable far-term capabilities, and spawn game-changing innovations that can unlock new possibilities and make space activities more affordable and sustainable. A NASA focus on innovation and technology will enable new approaches to our current mission set and allow us to pursue entirely new missions for the Nation.
- Climate change research and observations, which will enable NASA to substantially accelerate and expand its Earth Science capabilities, including a replacement for the Orbiting Carbon Observatory, development of new satellites recommended by the National Academy of Sciences Decadal Survey, and development of smaller Venture class missions. This investment will ensure the critically important continuity of certain key climate measurements and enable new measurements to address unknowns in the climate system, yielding expanded understanding of our home planet and improved understanding of climate change.
- Aeronautics research and development, including critical areas of the Next Generation Air Transportation System, environmentally responsible aviation, and safe integration of unmanned aircraft systems into the national airspace.
- Education initiatives, including the recently announced Summer of Innovation pilot program involving NASA scientist and curricula to inspire middle-school students and their teachers with exciting experiences that spur those students to continue in STEM careers.

I wish to emphasize that NASA intends to work closely with the Congress, including this Committee, to make a smooth transition to the new Exploration program, called for in the President's request, working responsibly on behalf of the taxpayers. With my deepest gratitude, I commend the hard work and dedication that thousands of NASA and contractor workers have devoted to Constellation over the last several years. Their commitment has brought great value to the Agency and to our Nation, and they will continue to play a pivotal role in NASA's future path. Many of the things NASA has learned from the Constellation program will be critical as the Agency moves forward.

The following contains more detail on the summary points made above, in the standard budget order for NASA's appropriation accounts.

Science

The President's FY 2011 request for NASA includes $5,005.6 million for Science. The NASA Science Mission Directorate (SMD) continues to expand humanity's understanding of our Earth, our Sun, the solar system and the universe with 59 science missions in operation and 30 more in various stages of development. The Science budget funds these missions as well as the research of over 3,000 scientists and their students across our Nation. The recommendations of the National Academies/National Research Council (NRC) decadal surveys help to guide SMD in setting its priorities for strategic science missions; and SMD selects competed missions and research proposals based on open competition and peer review.

The FY 2011 budget request for Science includes $1,801.7 million for **Earth Science**. This request increases investment in Earth Science by $1.8 billion from FY 2011 to FY 2014 compared to the FY 2010 budget, for a more aggressive response to the challenge of climate change. NASA will rapidly develop an Orbiting Carbon Observatory-2 mission for launch early in 2013 and a GRACE Follow-On mission for launch in late 2015, respectively, to initiate and extend key global climate data sets. This request accelerates several high-priority Decadal Survey missions that will advance climate research and monitoring. The increased funding accelerates launch of the Soil Moisture Active/Passive (SMAP) mission by six months from its estimated date at the recent Agency Key Decision Point (KDP)-B review, to November 2014. ICESAT–2 is advanced by five months relative to the estimated date at its recent Agency KDP–A review, to October 2015. The Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission and the Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) mission are each accelerated by two years, with both launching in late 2017. Thus, the budget request allows all four Tier-1 Decadal Survey missions to be launched between 2014 and 2017. In addition, NASA—working with the U.S. Global Change Research Program—will be able to identify and begin development for accelerated launch of selected Tier-2 Decadal Survey missions focused on climate change. The budget supports critical continuity of climate observations, including a Stratospheric Aerosol and Gas Experiment III (SAGE III) instrument to be developed for deployment on the ISS, while also supporting an accelerated pace of smaller "Venture class" missions. Finally, increased resources for Earth Science will allow NASA to expand key mission-enabling activities, including carbon monitoring, technology development, modeling, geodetic ground network observations, and applications development including the highly successful SERVIR program.

At present, NASA Earth-observing satellites provide the bulk of the global environmental observations used for climate change research in the United States and abroad. This year, analyses of NASA satellite measurements quantified the rates of ground water depletion since 2003 in California and in India's Indus River valley—rates that are unsustainable for the future. NASA conducted the first ICEBridge airborne campaigns in both Arctic and the Antarctic, to maintain the critical ice measurements during the gap in time between the ICESAT–1 and –2 satellites.

In FY 2011, the Glory and Aquarius missions will launch; and FY 2011 should close with the launch of the NPOESS Preparatory Project. The Landsat Data Continuity Mission will complete spacecraft integration and test, the Operational Land Imager will be delivered, and the Thermal Infrared Sensor will continue development. The Global Precipitation Mission will complete its System Integration Review in preparation for the beginning of assembly, integration and testing. During FY 2011, the SMAP mission will transition from formulation to development, and ICESAT–2 will begin design. Also in FY 2011, instrument development and observations initiated under the first Venture class solicitation for sustained airborne missions will reach full funding, and the next Venture class solicitations will be released-this time for space-based mission instrument, and complete mission, developments. Engineering studies and focused, actively-managed technology investments—instruments, components, and information systems—continue for the suite of future missions recommended by the National Research Council (NRC) Decadal Survey. In FY 2011, the Earth Science Technology Program will make additional, competitively-selected, instrument technology investments to meet decadal survey measurement goals. Earth Science Research and Applied Sciences Programs will continue to employ satellite observations to advance the science of climate and environmental change, mitigation, and adaptation. NASA will demonstrate the use of Uninhabited Aerial Systems in field campaigns addressing atmospheric trace gas composition and hurricane genesis, and NASA's modeling and data analysis efforts will con-

tribute to assessment activities of the Intergovernmental Panel in Climate Change and the U.S. Global Change Research Program.

The FY 2011 budget request for Science includes $1,485.8 million for **Planetary Science**. The current NASA planetary missions continue to make new discoveries and return fascinating images, including a previously unknown large and askew ring of Saturn and a near-complete map of the surface of Mercury. Mars continues to intrigue with signs of water ice just below the surface at mid-latitudes. The Mars rover Spirit is now an in situ science prospector, while Opportunity continues to roll toward the crater Endeavor. The Moon Mineralogy Mapper instrument on India's Chandrayaan-1 mission detected small amounts of water and hydroxyl molecules at unexpectedly low latitudes on the lunar surface. NASA selected three new candidate mission concepts for further study under the New Frontiers program, and will select the winning concept in FY 2011 to proceed to development. NASA will issue its next Discovery Announcement of Opportunity this year, and will select mission concepts and fund concept studies in FY 2011. NASA will also begin Advanced Stirling Radioisotope Generator development in FY 2011 to be available as an option to improve the performance of the radioisotope-fueled power sources for use in the next Discovery mission. The Mars Science Laboratory will complete development in FY 2011 for launch in fall 2011, beginning the most comprehensive astrobiology mission to the Red Planet to date. The MAVEN Mars aeronomy mission will continue development for launch in late 2013. NASA will establish a joint Mars Exploration Program with the European Space Agency (ESA) with a trace gas orbiter mission, including a European technology demonstration lander. In FY 2011, NASA plans to select instruments for the mission via a joint Announcement of Opportunity. To advance scientific exploration of the Moon, NASA will launch the GRAIL mission in late 2011 and continue development of LADEE for launch in 2013. Continuing its exploration of the outer planets, NASA will launch the Juno mission to Jupiter in August 2011. NASA will continue studies that support the possibility of a new major Outer Planets Mission concept pending the outcome of the NRC decadal survey now in progress, and will coordinate with ESA on a solicitation for science instruments. The new NRC Decadal Survey in Planetary Science should be complete in FY 2011. The FY 2011 budget request increases NASA's investment in identification and cataloging of Near Earth Objects and, with the Department of Energy, begins funding the capability to restart Plutonium-238 production here in the United States.

The FY 2011 budget request for Science includes $1.076.3 million for **Astrophysics**. The golden age of Astrophysics from space continues, with 14 observatories in operation. Astrophysics research, technology investments, and missions aim to understand how the universe works, how galaxies, stars and planets originated and developed over cosmic time, and whether Earth-like planets—and possibly life—exist elsewhere in the cosmos. The NASA Kepler telescope has discovered five exoplanets, ranging in size from Neptune to larger than Jupiter, demonstrating that the telescope is functioning as intended; additional discoveries are anticipated in the coming months and years. NASA's newest space observatory, WISE (Wide-Field Infrared Explorer), has captured its first look at the starry sky and its sky survey in infrared light has begun. Radio astronomers have uncovered 17 millisecond pulsars in our galaxy by studying unknown high-energy sources detected by the Fermi Gamma-ray Space Telescope.

The Hubble Space Telescope is operating at its peak performance thanks to the very successful servicing mission last year by the STS–125 crew. The Herschel and Planck missions, led by the European Space Agency with NASA as a partner, launched in 2009 and are returning remarkable scientific results. In FY 2011, NASA will complete most of the development of the NuSTAR mission and prepare it for launch. NASA will also begin developing the Gravity and Extreme Magnetism (GEMS) mission recently selected in the Explorer small satellite program. The James Webb Space Telescope (JWST) continues to make good progress in development toward a 2014 launch. Flight hardware for the many JWST subsystems is being designed, manufactured and tested, including the 18 segments of its 6.5-meter primary mirror; and the mission-level Critical Design Review for JWST will occur this spring. The SOFIA airborne observatory successfully conducted its first open-door flight test in December 2009—a major milestone toward the beginning of early science operations this year. The NRC is conducting a new Decadal Survey in astronomy and astrophysics, which will set priorities among future mission concepts across the full spectrum of Astrophysics, including dark energy, gravity wave, and planet-finding missions; the "Astro2010" Decadal Survey is expected in September.

The FY 2011 budget request for Science includes $641.9 million for **Heliophysics**. The Heliophysics operating satellites provide not only a steady stream of scientific data for the NASA research program, but also supply a significant fraction of critical space weather data used by other government agencies for support of commer-

cial and defense activities in space. These data are used for operating satellites, optimization of power transmission networks, and supporting communications, aviation and navigation systems. The NASA Aeronomy of Ice in Mesosphere (AIM) satellite has provided the first comprehensive, global-scale view of the complex life cycle of Earth's highest clouds, Polar Mesospheric Clouds, finding clues to why they appear to be occurring at lower latitudes than ever before. The STEREO B spacecraft recently observed a sunspot behind the Sun's southeastern limb—before it could be seen from Earth. In a few days, this sunspot produced five Class M solar flares of the kind that disturb radio signals on Earth, signaling the end of the Sun's extended quiet period of recent years. The Solar Dynamic Observatory (SDO), launched on February 11, will provide images of the Sun of unprecedented resolution, yielding new understanding of the causes of solar variability and its impact on Earth. In FY 2011, the Radiation Belt Storm Probes mission will complete hardware manufacturing and begin integration and testing. The Solar Orbiter Collaboration with the European Space Agency will continue in formulation, and the Solar Probe Plus mission will undergo an initial confirmation review at the end of FY 2011. The Magnetospheric Multi-scale mission will continue development toward a Critical Design Review. IRIS, a recently selected small Explorer mission, will hold its Critical Design Review in FY 2011. The next Explorer Announcement of Opportunity will be released in 2010, with selection for Phase A studies in FY 2011. NASA is working with the NRC to arrange for the next decadal survey in Heliophysics.

Aeronautics Research

The U.S. commercial aviation enterprise is vital to the Nation's economic well-being, directly or indirectly providing nearly one million Americans with jobs. In 2008 aerospace manufacturing provided the Nation with a trade surplus of over $57 billion. In the United States, more than 60 certified domestic carriers operate more than 28,000 flights daily, moving nearly one million travelers each day. We expect these flights to be safe, affordable, and convenient. We expect airlines to offer flights when and where we want to travel. In business and in our personal lives, the aviation industry is a key enabler to our way of life and the smooth functioning of our economy. However, the air transport system is near maximum capacity given today's procedures and equipment. Rising concerns about the environmental and noise impacts of aviation further limit future growth.

The FY 2011 budget request for Aeronautics is $579.6 million, an increase of $72.6 million, which will strongly support our existing portfolio of research and development to directly address these most critical needs of the Nation and enable timely development of the Next Generation Air Transportation System (NextGen). Through a balanced research and development portfolio, NASA's Aeronautics Research Mission Directorate (ARMD) is exploring early-stage innovative ideas, developing new technologies and operational procedures through foundational research, and demonstrating the potential of promising new vehicles, operations, and safety technology in relevant environments. Our goals are to expand capacity, enable fuel-efficient flight planning, reduce the overall environmental footprint of airplanes today and, in the future, reduce delays on the ground and in the sky, and improve the ability to operate in all weather conditions while maintaining the current high safety standards we demand.

The FY 2011 budget request for Aeronautics includes $228.5 million for the **Fundamental Aeronautics Program**, which seeks to continually improve technology that can be integrated into today's state-of-the-art aircraft, while enabling game-changing new concepts such as Hybrid Wing Body (HWB) airframes which promise reduced drag (thus improving fuel bum) and open-rotor engines which offer the promise of 20 percent fuel burn reduction compared to today's best jet engines. In partnership with Boeing and the Air Force, NASA has completed over 75 flights of the X48B sub-scale HWB aircraft at Dryden Flight Research Center in the last two years to explore handling and control issues. NASA is partnering with General Electric and Boeing to evaluate performance and integration of new open-rotor engine concepts in propulsion wind tunnels at the Glenn Research Center. NASA is also addressing key challenges to enable new rotorcraft and supersonic aircraft, and conducting foundational research on flight at seven times the speed of sound. American Recovery and Reinvestment Act funds have enabled NASA to re-commission a full-scale airframe structural test facility and to improve wind tunnels at the Langley, Ames, and Glenn Research Centers that are needed to assess new concepts that hold the promise of significant reductions in aircraft weight and fuel consumption. In partnership with industry, NASA has just initiated the first new government-funded effort on low NOx combustors in 15 years. In FY 2011, NASA will invest $30.0 million to design, build, and demonstrate a new generation of aircraft engine

combustors that will lower the emission of harmful nitrogen oxides by 50 percent compared with current combustors while ensuring compatibility with current and future alternative aviation fuels.

A key research goal is to develop synthetic and bio-derived alternatives to the petroleum-derived fuel that all jet aircraft have used for the last 60 years, but little is known about the emissions characteristics of these alternative fuels. In 2009, NASA led a team of eight partners from government agencies, industry, and academia in measuring emissions from an aircraft parked on the ground operating on various blends of synthetic and standard jet fuel. This team discovered that synthetic fuel blends can reduce particulate emissions by as much as 75 percent compared to conventional jet fuels, which would offer a major improvement in local air quality around airports. Using results from this and other research efforts, NASA has established a publicly-available database of fuel and emissions properties for 19 different fuels and will perform similar tests on biofuels as they become available.

The FY 2011 budget request for Aeronautics includes $82.2 million for **Airspace Systems**. The focus of this program is to achieve reductions in environmental impact not only through new aircraft, engines, and fuels, but also through improved air traffic management procedures. Using flight data from just the top 27 airports in the country, NASA systems analysis results indicate that nearly 400 million gallons of fuel could be saved each year if aircraft could climb to and descend from their cruising altitude without interruption. Another 200 million gallons could be saved from improved routing during the cruise phase of flight. Achievement of such operations requires that aircraft spacing in the air and on-time arrival and departure from the regions around our major airports be greatly improved. New satellite-based navigation aids such as the ADS–B system that the Federal Aviation Administration (FAA) is installing throughout the country can enable these improvements, but safe and efficient operational procedures must first be developed, validated, and certified for operational use. In 2009, NASA partnered with FAA, United Airlines, and Air Services Australia to validate pilot and controller procedures for a new concept originally developed by NASA that enables aircraft to safely conduct climbs and descents outside radar coverage in close proximity to nearby traffic. NASA also provided safety analyses needed for regulatory approval. The procedures benefit both airlines and the traveling public by providing long-haul oceanic flight with easier access to fuel-efficient, turbulence-free altitudes. United Airlines is expected to begin flying the oceanic in-trail procedures on revenue flights in May 2011.

The FY 2011 budget request for Aeronautics includes $113.1 million for the **Integrated Systems Research Program**. Begun in FY 2010, this program evaluates and selects the most promising "environmentally friendly" engine and airframe concepts emerging from our foundational research programs for integration at the systems level. In FY 2011, the program will test integrated systems in relevant environments to demonstrate that the combined benefits of these new concepts are in fact greater than the sum of their individual parts. Similarly, we are integrating and evaluating new operational concepts through real-world tests and virtual simulations. These efforts will facilitate the transition of new capabilities to manufacturers, airlines and the FAA, for the ultimate benefit of the flying public. In addition to strongly supporting our ongoing research portfolio, the FY 2011 budget request includes increased funding to expand our research in new priority areas identified through close consultation with industry, academia and other Federal agencies. In FY 2011, NASA will initiate a $30 million targeted effort to address operational and safety issues related to the integration of unmanned aircraft systems into the National Airspace System and augment research and technology development efforts by $20 million, including grants and cooperative agreements, to support NASA's environmentally responsible aviation research.

The FY 2011 budget request for Aeronautics includes $79.3 million for the **Aviation Safety Program**. This program conducts research to insure that aircraft and operational procedures maintain the high level of safety which the American public has come to count on. Safety issues span aircraft operations, air traffic procedures, and environmental hazards and this program is supporting research and delivering results in all three areas. American carriers operate 6,500 aircraft on more than 28,000 flights daily. For most of the day the FAA is controlling more than 4,000 aircraft in the sky at the same time. Further increases in capacity will require increased levels of automation for command and control functions and to analyze vast amounts of data, as well as increased complexity of the overall system. It now costs more to prove today's flight-critical systems are safe than it does to design and build them. The Joint Planning and Development Office has identified Verification and Validation (V&V) of aviation flight-critical hardware and software systems as one of the major capability gaps in NextGen. Therefore in FY 2011, NASA is initiating a new $20 million research activity in V&V of aviation flight-critical systems to de-

velop methodologies and concepts to effectively test, validate and certify software-based systems that will perform reliably, securely, and safely as intended.

NASA will continue to tackle difficult issues that threaten the safety of commercial flight, ranging from human/machine interaction to external hazards such as weather and icing, as the aircraft industry has come to rely on NASA expertise in predicting the effects of icing on aircraft performance at low and intermediate altitudes. However, over the last ten years a new form of icing problem has surfaced, occurring primarily in equatorial regions at high cruise altitudes and causing engine power loss or flameout. These conditions cannot be duplicated in any existing ground test facility. To study this problem, in 2009 NASA initiated an effort to modify the Propulsion Systems Laboratory at the Glenn Research Center to enable research on ways to mitigate the effects of high-altitude icing and development of new engine certification procedures.

The FY 2011 budget request for Aeronautics includes $76.4 million for the **Aeronautics Test Program** (ATP), which makes strategic investments to ensure availability of national ground facilities and flight assets to meet the testing needs of NASA and the Nation. The program also invests in the development of new test instrumentation and test technologies. One such example is ATP's collaboration with the Aviation Safety Program to provide a new testing capability in the NASA–Glenn PSL facility to address the threat of high-altitude ice crystals to jet engine operability. The program recently demonstrated for the first time the ability to generate ice crystals at the very cold temperatures (-60 °F) encountered at commercial aircraft cruise altitudes. The PSL high-altitude ice crystal capability will become operational in FY 2011. The program also completed the development of a new Strategic Plan to provide the vision and leadership required to meet national goals; provide sustained support for workforce, capability improvements, and test technology development; and provide strategic planning, management, and coordination with NASA, government, and industry stakeholders. This plan will provide informed guidance as ATP develops a critical decision tool for building well-coordinated national testing capabilities in collaboration with the Department of Defense through the National Partnership for Aeronautical Testing (NPAT).

Partnerships with industry, academia, and other Federal agencies are critical to the success and relevance of NASA research. Through close collaboration, NASA ensures that it works on the right challenges and improving the transition of research results to users. NASA is using NASA/FAA Research Transition Teams (RTTs) to conduct joint research and field-trials to speed acceptance of new air traffic management procedures. The Agency is also coordinating management and operation of the Federal Government's large aeronautics ground test infrastructure through the NPAT. Through NASA Research Announcements (NRAs), NASA solicits new and innovative ideas from industry and academia while providing support for Science, Technology, Engineering, and Math departments. The Agency also funds undergraduate and graduate scholarships, Innovation in Aeronautics Instruction grants to improve teaching programs at the university level, and sponsor student design competitions at undergraduate and graduate levels for both U.S. and international entrants. By directly connecting students with NASA researchers and our industrial partners we become a stronger research organization while inspiring students to choose a career in the aerospace industry.

Exploration

The FY 2011 budget request for Exploration is $4,263.4 million, an increase of $483.6 million above the FY 2010 enacted level. Included in this budget request is funding for three new, robust programs that will expand the capabilities of future space explorers far beyond those we have today. NASA will embark on these transformative initiatives by partnering with the best in industry, academia and other government agencies, as well as with our international partners. These partners have been integral to much of NASA's previous success and are vital to our bold new vision.

NASA will encourage active public participation in our new exploration missions via a new participatory exploration initiative. Additionally, the FY 2011 budget request builds upon NASA's commercial cargo efforts by providing significant funding for the development of commercial human spaceflight vehicles, freeing NASA to focus on the forward-leaning work we need to accomplish for beyond-LEO missions. The FY 2011 budget request is a 40 percent increase over last year's investment in the Human Research Program, to help prepare for future human spaceflight exploration beyond low-Earth orbit. Lastly, the Exploration FY 2011 budget request includes funding for the Constellation Program close-out activities spread across FY 2011 and FY 2012.

In the near term, NASA is continuing Constellation work to ensure an orderly closeout of the program in FY 2011 and to capture of all of the knowledge learned through its key efforts. The Constellation Program is focusing on completing its Preliminary Design Review (PDR), which will conclude this year. NASA believes that completing the Constellation PDR will support not only the close-out process for Constellation, but also will ensure that historical data from Constellation work is documented, preserved and made accessible to future designers of other next-generation U.S. human spaceflight systems.

The Exploration FY 2011 budget request includes three new robust research and development programs that will enable a renewed and reinvigorated effort for future crewed missions beyond low-Earth orbit:

- **Technology Development and Demonstration Program**: $652.4 million is requested in FY 2011, and a total of $7,800.0 million is included in the five year budget plan, to invent and demonstrate large-scale technologies and capabilities that are critical to future space exploration, including cryo-fluid management and transfer technologies; rendezvous and docking technologies; and closed-loop life support systems. These technologies are essential to making future exploration missions more capable, flexible, and affordable.
- **Heavy-Lift and Propulsion Research and Development Program**: $559.0 million is requested in FY 2011, and a total of $3,100.0 million is included in the five-year budget plan, for an aggressive, new heavy-lift and propulsion R&D program that will focus on development of new engines, propellants, materials and combustion processes that would increase our heavy-lift and other space propulsion capabilities and significantly lower operations costs—with the clear goal of taking us farther and faster into space consistent with safety and mission success.
- **Robotic Exploration Precursor Program**: $125.0 million is requested in FY 2011, and $3,000.0 million is included in the five-year budget plan, for robotic missions that will pave the way for later human exploration of the Moon, Mars and nearby asteroids. Like the highly successful Lunar Reconnaissance Orbiter and Lunar Crater Observation and Sensing Satellite missions that captured our attention last fall, future exploration precursor missions will scout locations and demonstrate technologies to locate the most interesting places to explore with humans and validate potential approaches to get them there safely and sustainably.

Cross-agency teams for each of these three areas are working to develop plans that delineate key areas for research and development, specify milestones for progress and set launch dates for relevant missions. They will report to the Administrator over the coming months, and the results of their efforts will be shared with the Congress when they are complete.

The Exploration FY 2011 budget request for **Commercial Spaceflight** is $812.0 million, which includes $500.0 million to spur the development of U.S. commercial human spaceflight vehicles, and a total of $6 billion in the five-year budget plan. This investment funds NASA to contract with industry to provide astronaut transportation to the International Space Station as soon as possible, reducing the risk of relying solely on foreign crew transports, and frees up NASA resources to focus on the difficult challenges in technology development, scientific discovery, and exploration. We also believe it will help to make space travel more accessible and more affordable. An enhanced U.S. commercial space industry will create new high-tech jobs, leverage private sector capabilities and energy in this area, and spawn other businesses and commercial opportunities, which will spur growth in our Nation's economy. And, a new generation of Americans will be inspired by these commercial ventures and the opportunities they will provide for additional visits to space. NASA plans to allocate this FY 2011 funding via competitive solicitations that support a range of activities such as human-rating existing launch vehicles and developing new crew spacecraft that can ride on multiple launch vehicles. NASA will ensure that all commercial systems meet stringent human-rating and safety requirements before we allow any NASA crew member (including NASA contractors and NASA-sponsored International partners) to travel aboard a commercial vehicle on a NASA mission. Safety is, and always will be, NASA's first core value.

In addition to the $500 million identified for crew transportation development efforts, the budget also includes $312.0 million in FY 2011 for incentivizing NASA's current commercial cargo program. These funds—by adding or accelerating the achievement of already-planned milestones, and adding capabilities or tests—aim to expedite the pace of development of cargo flights to the ISS and improve program robustness.

Today, NASA is using $50.0 million from the *American Recovery and Reinvestment Act of 2009* to help drive the beginnings of a commercial crew transportation industry. Through an open competition, in early February, NASA awarded Space Act Agreements to five companies who proposed ideas and concepts intended to make commercial crew services a reality. While there are many vibrant companies out there that we hope to partner with in the future, these five companies, along with our two currently funded Commercial Orbital Transportation Services partners (Space Exploration Technologies and Orbital Sciences Corporation) are at the forefront of a grand new era in space exploration.

The Exploration FY 2011 budget request includes $215.0 million for the **Human Research Program**, an increase of more than 40 percent over the FY 2010 enacted level, and an investment of $1,075 million over the five-year budget plan. The Human Research Program is a critical element of the NASA human spaceflight program in that it develops and validates technologies that serve to reduce medical risks associated for crew members.

The Exploration FY 2011 budget request includes $1,900.0 million for **Constellation Closeout** requirements, and a total of $2,500.0 million over the FY 2011–2012 timeframe. These funds will be used for related facility and close-out costs, potentially including increased costs for Shuttle transition and retirement due to Constellation cancellation. The Agency has established senior planning teams to outline options for Constellation close out expeditiously and thoughtfully and to assess workforce, procurement and other issues, which will report to the Administrator over the coming months, to ensure that people and facilities are best utilized to meet the needs of NASA's new missions. NASA will work closely with the Congress as these activities progress.

NASA recognizes that this change will personally affect thousands of NASA civil servants and contractors who have worked countless hours, often under difficult circumstances, to make the Constellation Program successful. I commend the investment that these dedicated Americans have made and will continue to make in our Nation's human spaceflight program. Civil servants who support Constellation should feel secure that NASA has exciting and meaningful work for them to accomplish after Constellation, and our contractor colleagues should know that NASA is working expeditiously to identify new opportunities for them to partner with the Agency on the new Exploration portfolio.

Space Technology

Through the new Space Technology Program, led by the recently established Office of the Chief Technologist, NASA will increase its support for research in advanced space systems concepts and game-changing technologies, enabling new approaches to our current mission set and allowing the pursuit of entirely new missions. Using a wide array of management, funding, and partnership mechanisms, this program will engage the brightest minds in private industry, across the NASA Centers, and throughout academia. This new program builds upon the success of NASA's Innovative Partnerships Program and directly responds to input from multiple NRC reports, as well as the Augustine Committee. The Space Technology program will meet NASA's needs for new technologies to support future NASA missions in science and exploration, as well as the needs of other government agencies and the Nation's space industry in a manner similar to the way NACA aided the early aeronautics industry. Many positive outcomes are likely from a long-term NASA advanced space systems concepts and technology development program, including a more vital and productive space future than our country has today, a means to focus NASA intellectual capital on significant national challenges and needs, a spark to renew the nation's technology-based economy, an international symbol of our country's scientific and technological leadership, and a motivation for many of the country's best young minds to enter into educational programs and careers in engineering and science.

The FY 2011 budget request for Space Technology is $572.2 million, and $4,925.9 million is included in the five-year budget plan. With this initiative, NASA will expand its Technology and Innovation portfolio to include: open competitions to stimulate highly innovative, early-stage space system concepts and ideas; development of technologies that can provide game-changing innovations to address NASA and national needs; and development and infusion of cross-cutting capabilities into missions that address needs from multiple NASA Mission Directorates, other government agencies, and commercial activities in space, while fostering and stimulating a research and development culture at NASA Centers. Beginning in FY 2011, activities associated with the Innovative Partnerships Program are transferred to Space Technology.

The need for advanced capabilities is increasing as NASA envisions missions of increasing complexity to explore and understand the Earth, our solar system, and the universe. Technology and innovation are critical to successfully accomplishing these missions in an affordable manner. The Space Technology program will enhance NASA's efforts to nurture new technologies and novel ideas that can revolutionize our aerospace industrial base, as well as to address national and global challenges and enable whole new capabilities in science and exploration that will be of benefit to the Nation. Key focus areas include communications, sensors, robotics, materials, and propulsion. The Space Technology program will use open competitions such as NASA Research Announcements and Announcements of Opportunity, targeted competitions such as those for small business (SBIR), universities (STTR), and engage early career scientists and engineers. NASA will also continue to use challenges and prizes to stimulate innovative new approaches to technology development and will encourage partnerships with both established and emerging commercial space industries. Through the three major elements of this program—Early-Stage Innovation, Game-Changing Innovation, and Crosscutting Capabilities—a broad suite of management, funding and partnership mechanisms are employed to stimulate innovation across NASA, industry and academia.

The Early-Stage Innovation program element sponsors a wide range of advanced space system concept and initial technology development efforts across academia, industry and the NASA Centers. This program element includes: (a) the Space Technology Research Grant program (analogous to the Fundamental Aeronautics program within NASA's Aeronautics Research Mission Directorate) that focuses on foundational research in advanced space systems and space technology, (b) re-establishment of a NIAC-like Program to engage innovators within and external to the Agency in accordance with the recommendations of the NRC's *Fostering Visions of the Future* report, (c) enhancement of the Innovative Partnership Programs Seed Fund into a Center Innovations Fund to stimulate aerospace creativity and innovation at the NASA field Centers, (d) NASA's SBIR/STTR program to engage small businesses, and (e) the Centennial Challenges Prize Program to address key technology needs with new sources of innovation outside the traditional aerospace community. Competitive selection is a major tenet of all the activities within this low technology readiness level (TRL) program element.

The Game Changing Innovation program element focuses on maturing advanced technologies that may lead to entirely new approaches for the Agency's future space missions and solutions to significant national needs. Responsive to the NRC report, *America's Future in Space. Aligning the Civil Space Program with National Needs*, this program element demonstrates the feasibility of early-stage ideas that have the potential to revolutionize future space missions. Fixed-duration awards are made to PI-led teams comprised of government, academia and industry partners. These awards are evaluated annually for progress against baseline milestones with the objective of maturing technologies through ground-based testing and laboratory experimentation. NASA intends to draw from DARPA's experience to create and implement collaborative game-changing space technology initiatives. New technologies considered may include advanced lightweight structures and materials, advanced propulsion, power generation, energy storage and high bandwidth communications. With a focus on such potentially revolutionary technologies, success is not expected with each investment; however, on the whole, and over time, dramatic advances in space technology enabling entirely new NASA missions and potential solutions to a wide variety of our society's grand technological challenges are anticipated.

A Crosscutting Capabilities program element matures a small number of technologies that are of benefit to multiple customers to flight readiness status. Technical risk, technology maturity, mission risk, customer interest, and proposed cost are discriminators planned for use in the selection process. For infusion purposes, proposing teams are required to have a sponsor willing to cost share a minimum of 25 percent of the planned development effort. With objectives analogous to the former New Millennium program, NASA will pursue flight demonstrations not only as standalone missions, but also as missions of opportunity on planned NASA missions as well as international and commercial space platforms. The Commercial Reuseable Suborbital Research Program (which provides suborbital flight opportunities for technology demonstrations, scientific research and education), the Facilitated Access to the Space environment for Technology (FAST) project (which focuses on testing technologies on parabolic aircraft flights that can simulate microgravity and reduced gravity environments) and the Edison Small Satellite Demonstration Missions project (which develops and operates small satellite missions in partnership with academia). are also included in this program element.

NASA has had past success in the development of game-changing technologies and the transfer of its products and intellectual capital to industry. As an example,

consider the Mars Pathfinder mission of the early 1990s. In addition to accomplishing its science and technology objectives, Mars Pathfinder established surface mobility and ground truth as important exploration principles, created a groundswell of interest and a foundational experience for a new generation of Mars scientists and engineers, re-engaged the public with Mars as a destination worthy of exploration, led to the creation of NASA's Mars program and establishment of a Mars program budget line, and led to a wide spectrum of small missions to Mars, the asteroids, comets and other bodies in our solar system. For NASA's robotic exploration program, Mars Pathfinder was clearly a game-changer. In a more recent example, consider NASA's recent improvements to thermal protection system (TPS) materials through an Advanced Capabilities development project. Over three years, a NASA-industry team raised the TRL of 8 different TPS materials from 5 different commercial vendors, eventually selecting the best as the system for the Orion heat shield. In addition to providing a heat shield material and design for Orion on time and on budget, this Advanced Capabilities development project re-invigorated a niche space industry that was in danger of collapse, re-established a NASA competency able to respond to future TPS needs. For example, the team identified a potentially catastrophic problem with the planned MSL heat shield and remedied the problem by providing a viable alternate heat shield material and design within stringent schedule constraints. The mature heat shield material and designs have been successfully transferred to the commercial space industry, including the TPS solution for the SpaceX Dragon capsule. Beginning in FY 2011, the new NASA Space Technology program aims to strengthen and broaden these successful innovation examples across a wide range of NASA enterprises and significant national needs.

Space Operations

The FY 2011 budget request includes $4,887.8 million for Space Operations, funding the Space Shuttle program, the International Space Station Program, and the Space and Flight Support program.

The FY 2011 budget request for the **Space Shuttle** program is $989.1 million. In 2009, the Space Shuttle flew five times, delivering to the ISS its final set of solar arrays and the equipment needed to support a six-person permanent crew; servicing the Hubble Space Telescope; completing the assembly of the three-module Japanese Kibo science laboratory; outfitting the Station with two external payload and logistics carriers, the Materials Science Research Rack-1, the Fluid Integrated Rack, the Minus Eighty-Degree Laboratory Freezer, a treadmill, and air revitalization equipment; and, delivering key supplies.

In 2010, the Shuttle is slated to fly out its remaining four missions, including the recently completed STS-130 mission. In April, Shuttle Discovery will carry up critical supplies for the ISS using a Multi-Purpose Logistics Module (MPLM) and the Lightweight Multi-Purpose Experiment Support Structure Carrier (LMC). Atlantis will launch in May with the Russian Mini-Research Module–1, as well as the Integrated Cargo Carrier–Vertical Light Deployment (ICC–VLD). This summer, Endeavour will carry the Alpha Magnetic Spectrometer (AMS) and attach it to the Station's truss structure. The AMS is a particle physics experiment, which will use the unique environment of space to advance knowledge of the universe and contribute to understanding the universe's origin. AMS is presently undergoing critical thermal and electrical testing at the European test facilities in the Netherlands. If these tests are successful, AMS will ship to KSC in May for the July launch. The final Shuttle mission, STS–133, is targeted for September of this year. Discovery will carry supplies to ISS, as well as an MPLM that will be installed on ISS as a permanent module, expanding the Station's storage volume. This flight will mark the completion of ISS assembly.

For almost 30 years, the Space Shuttle has carried U.S. and international astronauts into orbit; played a key role in the construction, outfitting, and resupply of the ISS; serviced the Hubble Space Telescope five times; served as an Earth-orbiting laboratory through the Spacelab and SpaceHab missions; and deployed a diverse array of payloads, including science probes and research experiments (such as the Magellan mission to Venus and Earth-orbiting tether experiments), communications satellites; and even student projects. 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.

FY 2011 will be the first full year of major Space Shuttle Program (SSP) transition and retirement (T&R) activities. T&R is focused on the retirement of the SSP and the efficient transition of assets to other uses once they are no longer needed for safe mission execution. These activities include identifying, processing, and

safing hazardous materials, and the transfer or disposal of SSP assets, including the preparation of Orbiters and other flight hardware for public display. T&R also covers severance and retention costs associated with managing the drawdown of the SSP workforce.

A key element of America's future in space is the **International Space Station**. The FY 2011 budget request for the International Space Station Program is $2,779.9 million. As of May 2009, the ISS has been able to support a six-person permanent crew, and during the STS–127 mission last July, the Station hosted 13 astronauts representing the five space agencies in the ISS partnership, including those of the United States, Russia, Japan, Europe and Canada. The three major science labs aboard ISS were completed in 2009 with the delivery of the Exposed Facility of the Japanese Kibo module. In addition, the first flight of Japan's H–II Transfer Vehicle (HTV) was successfully carried out last fall, adding a new cargo-carrying spacecraft to the fleet.

This year will mark the completion of assembly of the ISS—the largest crewed spacecraft ever assembled, measuring 243 by 356 feet, with a habitable volume of over 30,000 cubic feet and a mass of 846,000 pounds, and powered by arrays which generate over 700,000 kilowatt-hours per year. The ISS represents a unique research capability aboard which the United States and its partner nations can conduct a wide variety of research in biology, chemistry, physics and engineering fields which will help us better understand how to keep astronauts healthy and productive on long-duration space missions. Funding for ISS research is also reflected in the Exploration budget request and in the Space Technology budget request.

The FY 2011 budget request includes a dramatic increase in the Nation's investment in the research and capabilities of the ISS. With this investment, NASA will be able to fully utilize the ISS and increase those capabilities through upgrades to both ground support and onboard systems. Importantly, this Budget extends operations of the ISS, likely to 2020 or beyond. This budget makes a strong commitment to continued and expanded operation of the ISS. The United States as leader in space made this first step and will now work with the other ISS international partners to continue International operation of the ISS. ISS can inspire and provide a unique research platform for people worldwide.

ISS research is anticipated to have terrestrial applications in areas such as biotechnology, bioengineering, medicine and therapeutic treatment. The FY 2011 budget request for ISS reflects increased funding to support the ISS as a National Laboratory in which this latter type of research can be conducted. NASA has two MOUs with other U.S. government agencies, and five 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. This budget request supports both an increase in research and funding for cargo transportation services to deliver experiments to the Station.

ISS can also play a key role in the demonstrations and engineering research associated with exploration. Propellant storage and transfer, life support systems, and inflatable technology can all benefit by using the unique research capabilities of ISS.

In addition to supporting a variety of research and development efforts, the ISS will serve as an incubator for the growth of the low-Earth orbit space economy. NASA is counting on its Commercial Resupply Services (CRS) suppliers to carry cargo to maintain the Station. The first CRS cargo flights will begin as early as 2011. It is hoped that these capabilities, initially developed to serve Station, may find other customers as well, and encourage the development of further space capabilities and applications. The suppliers involved will gain valuable experience in the development and operation of vehicles that can: 1) fly to the ISS orbit; 2) operate in close proximity to the ISS and other docked vehicles; 3) dock to ISS; and, 4) remain docked for extended periods of time.

As a tool for expanding knowledge of the world around us; advancing technology; serving as an impetus for the development of the commercial space sector; demonstrating the feasibility of a complex, long-term, international effort; and, perhaps most importantly, inspiring the next generation to pursue careers in science, technology, engineering, and mathematics, the ISS is without equal.

The FY 2011 budget request for **Space and Flight Support** (SFS) is $1,119.0 million. The budget request provided for critical infrastructure indispensable to the Nation's access and use of space, including Space Communications and Navigation (SCaN), the Launch Services Program (LSP), Rocket Propulsion Testing (RPT), and Human Space Flight Operations (HSFO). The SFS budget also includes a new and significant investment in the 21st Century Space Launch Complex, intended to 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 2011, the SCaN Program will begin efforts to improve the robustness of the Deep Space Network (DSN) by initializing the replacement of the aging 70m antenna capability with the procurement of a 34m antenna. The NASA DSN is an international network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe. The DSN also supports selected Earth-orbiting missions. In the third quarter, a System Requirements Review (SRR) of the Space Network Ground Segment Sustainment (SGSS) Project will be conducted, and the Program will have begun integration and testing of the Tracking and Data Relay Satellites (TDRS) K&L. In the area of technology, the Communication Navigation and Networking Reconfigurable Testbed (CoNNeCT) will be installed on ISS. This test bed will become NASA's orbiting SCaN laboratory on the ISS and will validate new flexible technology to enable greater spacecraft productivity. NASA will also have its first optical communication system ready for integration into the Lunar Atmosphere and Dust Environment Explorer (LADEE) spacecraft. In addition, the Disruption Tolerant Networking (DTN) protocols will complete their development at the end of FY 2011 and should be ready for operations throughout the solar system. The SCaN operational networks will continue to provide an unprecedented level of communications and tracking services to over 75 spacecraft and launch vehicles during FY 2011.

The LSP has six planned NASA launches in FY 2011 including Glory, Aquarius, Juno, Nuclear Spectroscopic Telescope Array (NuSTAR), NPOESS Preparatory Project (NPP) and the Gravity Recovery and Interior Laboratory (GRAIL) mission. In addition to processing, mission analysis, spacecraft integration and launch services, LSP 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. These facilities will support many of the tests planned under ESMD's propulsion research program.

HSFO includes Crew Health and Safety (CHS) and Space Flight Crew Operations (SFCO). SFCO will continue to provide trained crew for the manifested Space Shuttle requirements, four 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 space flight and how best to mitigate that risk.

The 21st Century Launch Complex initiative will primarily benefit NASA's current and future operations at the Kennedy Space Center (KSC), but will also help to improve KSC launch operations for future and current non-NASA users of the range, with the goal of transforming KSC into a modern facility. This new initiative focuses on upgrades to the Florida launch range, expanding capabilities to support commercial launch providers, such as commercial cargo flights and future commercial crew flights in support of ISS, and expendable launch vehicles in support of the Science mission directorate payloads and robotic precursor missions. Additional areas under consideration include modernization activities to support safer and more efficient launch operations; enhancing payload processing capabilities through capacity increases, improvement, and modernization, in addition to potentially relocating the KSC perimeter where appropriate and feasible, to enable certain existing private sector facilities to lie outside the security perimeter, thus making it far more convenient to use those facilities; environmental remediation to reduce the impact on the surrounding areas; and supporting the modernization of the launch range capabilities. We will fully coordinate this activity with all users of the range.

Education

The FY 2011 budget request for Education is $145.8 million. This budget request furthers NASA's commitment to inspiring the next generation of explorers in the STEM disciplines. In FY 2011, NASA will continue to strongly support the Administration's STEM priorities and will continue 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. This strategy will increase the distribution and impact of NASA progressive opportunities for elementary and secondary teachers, university faculty, students of all ages, and the public.

In FY 2011, NASA will support the Administration's STEM education teaching and learning improvement efforts, including Race to the Top and Educate to Innovate, while continuing efforts to incorporate NASA content into the STEM education initiatives of other Federal agencies. This summer, NASA will launch *Summer of*

Innovation, an intensive STEM teaching and learning program targeted at the middle school level that includes follow-on activities during the school year. NASA content and products will be incorporated into evidence-based summer learning programs across participating states with the goal of improving student academic performance and motivating them to pursue further education and successful careers. The FY 2011 request includes funding for *Summer of Innovation* over a three-year period.

NASA will also continue to partner with academic institutions, professional education associations, industry, and other Government agencies to provide K–12 teachers and university faculty with the experiences that capitalize on the excitement of NASA discoveries to spark their student's interest and involvement. Examples of such experiences are the NASA student launch initiatives and other hands-on payload development and engineering opportunities. The FY 2011 budget request also places increased emphasis on Education and cyber-learning opportunities and expands teacher pre-service, professional development and training programs. Additionally, NASA seeks to prepare high school students for undergraduate STEM study through experiences that blend NASA research and engineering experiences with classroom study and mentoring. Another Agency education goal is to broaden community college participation in NASA research and STEM workforce development.

In FY 2011, the Agency aims to increase both the use of NASA resources and the availability of opportunities to a diverse audience of educators and students, including women, minorities, and persons with disabilities. An example is the Innovations in Global Climate Change Education project that will be implemented within the Minority University Research and Education Program. The project will seek innovative approaches to providing 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

NASA Cross-Agency Support 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. Cross-Agency Support includes two themes: Center Management and Operations and Agency Management and Operations. The FY 2011 budget request includes $3,310.2 million for Cross-Agency Support.

NASA's FY 2011 budget request includes $2,269.9 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 continue to provide high-quality support and the technical talent for the execution of programs and projects.

NASA's FY 2011 budget request includes $1,040.3 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, and Strategic Capabilities Assets Program. Beginning in FY 2011, activities associated with the Innovative Partnerships Program are transferred to the Space Technology program. The FY 2011 budget request provides:

- $428.1 million for **Agency Management**, which supports executive-based, Agency-level functional and administrative management requirements. 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.
- $201.6 million for **Safety and Mission Success** activities required to continue strengthening the workforce, training, and strengthening the fundamental and robust checks and balances applied on the execution of NASA's mission, and to improve the likelihood for safety and mission success for NASA's programs, projects, and operations. The engineering, safety and mission assurance, health and medical independent oversight, and technical authority components are essential to NASA's success and were established or modified in direct response to many of the key *Challenger* and *Columbia* accident board recommendations for reducing the likelihood for future accidents.

Included under Safety and Mission Success is the Software Independent Verification and Validation program.

- $177.8 million for **Agency Information Technology Services**, which encompasses cross-cutting services and initiatives in IT management, applications, and infrastructure necessary to enable the NASA Mission and improve security, integration and efficiency of Agency operations. NASA plans significant emphasis on continued implementation of five major Agency-wide procurements to achieve the following: (1) consolidation of IT networks leading to improved network management, (2) consolidation of desktop/laptop computer services and mobile devices to improve end-user services, (3) data center consolidation to provide more cost-effective services, (4) Agency public web site management to improve access to NASA data and information by the public, and (5) Agency business systems development and maintenance to provide more efficient and effective business systems. NASA will also continue to improve security incident detection, response, and management through the Security Operations Center.
- $29.8 million for the **Strategic Capabilities Assets Program** (SCAP). This program funds the costs required to sustain 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.

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 for closed facilities, and environmental compliance and restoration. The FY 2011 budget request includes $397.4 million for Construction and Environmental Restoration, made up of:

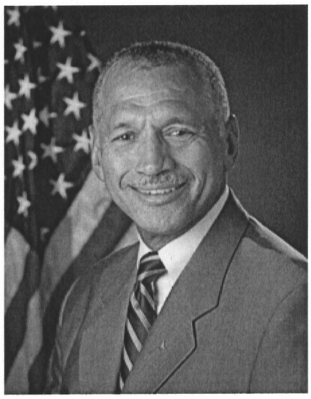
- $335.3 million for the **Construction of Facilities** (CoF) Program, which funds capital repairs and improvements to ensure that facilities critical to achieving NASA's space and aeronautics program are safe, secure, environmentally sound, and operate efficiently. The Agency continues to place emphasis on achieving a sustainable and energy-efficient infrastructure by replacing old, inefficient, deteriorated building with new, efficient, high performance buildings that will meet NASA's mission needs while reducing future operating costs.
- $62.1 million for **Environmental Compliance and Restoration** (ECR) Program, which supports the ongoing cleanup of current or former 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 for future missions. This program also supports strategic investments in environmental methods and practices aimed at reducing NASA's environmental footprint and lowering the risks of future cleanups.

Conclusion

Americans and people worldwide have turned to NASA for inspiration throughout our history—our work gives people an opportunity to imagine what is barely possible, and we at NASA get to turn those dreams into real achievements for all humankind. This budget gives NASA a roadmap to even more historic achievements as it spurs innovation, employs Americans in fulfilling jobs, and engages people around the world as we enter an exciting new era in space. NASA looks forward to working with the Committee on implementation of the FY 2011 budget request.

Mr. Chairman, thank you for your support and that of this Committee. I would be pleased to respond to any questions you or the other Members of the Committee may have.

BIOGRAPHY FOR CHARLES F. BOLDEN, JR.



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

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

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

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

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

Bolden was assigned as the Deputy Commanding General of the 1st Marine Expeditionary Force in the Pacific in 1997. During the first half of 1998, he served as Commanding General of the 1st Marine Expeditionary Force Forward in support of Operation Desert Thunder in Kuwait. Bolden was promoted to his final rank of major general in July 1998 and named Deputy Commander of U.S. Forces in Japan. He later served as the Commanding General of the 3rd Marine Aircraft

Wing at Marine Corps Air Station Miramar in San Diego, Calif., from 2000 until 2002, before retiring from the Marine Corps in 2003. Bolden's many military decora-

tions include the Defense Superior Service Medal and the Distinguished Flying Cross. He was inducted into the U.S. Astronaut Hall of Fame in May 2006.

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

Chairman GORDON. Thank you, sir. At this point we will begin our first round of questions, and the Chairman recognizes himself for five minutes.

You have laid out an exciting agenda for NASA. Certainly there were many other areas that NASA encourages outside of the human exploration, and I am glad that you have really a bold agenda there.

But the questions that have been raised most often have been about the exploration program, so let me go back to my original opening statement when I asked or sort of pointed out as we are going through a too-big-to-fail trauma right now for the taxpayers and the economy, my concern is that we could get into a too important to fail.

So if we—if the companies that are going to provide the commercial crew transportation don't have other markets, then are we going to wind up having to support them. So can you give me some type of concrete evidence that there will be other markets for their services?

Mr. BOLDEN. Mr. Chairman, the evidence that I have used has been the studies that have come from the industry themselves, from the commercial market. You know, unfortunately, it is not—we at NASA have not done any market surveys nor have, you know, have I offered to do that or asked to do it, so I am depending upon surveys and information that has come from the industry themselves.

Chairman GORDON. Well, and I don't say that they are bad folks, but this is a little bit like the fox looking after the hen house, isn't it? I mean, if you are getting information from them that justifies themselves, I would encourage you to—I think certainly NASA needs to look into this. I think it would make it a much more comfortable situation for many of us if we thought that they weren't going to be wards of the state or of NASA.

And so let me just say that is not a satisfactory answer and I would hope that you could get us some more information.

And in that regard in the request, your budget request, you asked for a 62 percent increase on what the government had, what the companies had previously said would be necessary. Where did this increase come from?

Mr. BOLDEN. Mr. Chairman, when we priced what we were going to ask for in the budget for the commercial, the COTS Program and other commercial endeavors, we looked at past cost for programs, we looked at what industry estimates for programs, and we asked several of the companies what they thought it would cost for a program of this nature, and that is where the cost estimates come from.

Chairman GORDON. Well, didn't just recently within the last year or two the companies said they could do this for less, which is the result of the 62 percent increase?

Mr. BOLDEN. Sir, let me go—I will get an answer for you for the record for that, because there have been some companies who have come in within the last few months that said they could do it quicker. I am not aware of any that have said they could do it for less. So I will get you an answer for the record for the that.[1]

Chairman GORDON. Where this is going is part of the reason that—the justification from moving from Constellation to a different approach is expense, and so if we—if it is not going to be less expensive, then there has to be a better explanation I think why this move.

And so finally, Administrator Bolden, there appears to be some confusion among individuals at your agency as to whether money from the Constellation Program needs to be set aside this fiscal year to avoid violating the Anti-Deficiency Act. So to make certain that we are all on the same page, I wonder if you would agree that the following is the current situation.

In 2010, Commerce, Justice, and Science Appropriation Act explicitly instructed NASA, and I quote, that "none of these funds provided herein shall be available for the termination or elimination of any program, project, or activity of the architecture of the Constellation Program nor shall such funds be available to create or initiate a new program, project, or activity unless such program termination, elimination, creation, or initiation is provided in subsequent appropriation acts." Is that a fair, I mean, is that your understanding?

Mr. BOLDEN. That is my understanding, Mr. Chairman, and in fact, that is in, I think, a letter that I sent recently to 27 members of the House who questioned what we were doing with the Constellation Program. As I told them, we were not—we were in compliance with the direction of the 2010 Appropriations Act and that I have directed no cancellations or terminations and that we intended to comply with the law.

Chairman GORDON. Well, so then could you explain the letters that NASA is sending to the Constellation contractors? I have one example here in which NASA is asking for estimates of the termination liability costs for this quarter as well as the next three quarters. This seems to indicate that NASA is contemplating cancellation, canceling Constellation contracts in the very near term.

In fact, this letter which was sent out on February the 22nd, asks for a response by March the 5th, next Friday.

Mr. BOLDEN. And, sir, and that was covered in the letter that I did send in responding to the Members of Congress. What I tried to explain was that I think it is fiscally responsible on my part and expedient that I try to get estimates from the companies as to what they feel their termination costs would be if, in fact, the President's direction that we cancel the Constellation Program in 2011 were to take effect. It was—it is a planning figure for us, and it is not direction to do anything. I asked them to make sure that we can see their numbers for what it would be to fund termination.

Chairman GORDON. But wouldn't it be more appropriate to ask for the termination costs in 2011 rather than cancellation costs at this quarter?

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[1] Page 20, line 409, of the transcript (see Appendix 2: Additional Material for the Record).

Mr. BOLDEN. Mr. Chairman, let me go back and check, double check for the record, but I think I was asking for what would be the termination cost if the President's direction were carried out that we cancel the program.[2]

Chairman GORDON. Well, again, the letter that we have indicates that it is—they start with this quarter. "Please provide your estimate termination liability for the subject contract as a part of this in each of the 3 quarters as of April the 1st, 2010, July the 1st, 2010, October the 1st, 2010, January the 1st, 2011."

And this went over the signature of Terrell Cochran.

Mr. BOLDEN. Yes, sir.

Chairman GORDON. I think I don't want to abuse my time, and so, Mr. Olson, you are recognized for five minutes.

Mr. OLSON. Thank you very much, Mr. Chairman, and thank you, Administrator Bolden, for your appearance here today before this Committee. Always good to have someone from the home turf here in this hearing room.

Mr. Master, I have got—or Mr. Administrator, I have got a couple concerns and questions I would like to ask you. One of them is sort of the process with which this decision was made, because if you read some media reports and hear some things in the community, it seemed to be made by a very small cabal for lack of a better term, of people here in Washington, DC. I know for a fact that no one at the Johnson Space Center was consulted about the decision to terminate the Constellation. And I particularly want to make sure that you were involved in that decision, so I ask you, I mean, this is the largest cut in the President's budget. Did you hear directly from the President on this?

And, again, this is important to me. I have got to go back home and explain to my constituents who—and many of them in their case, unfortunately, are losing their jobs, I've got to explain this to them. And I can't just say this was an OMB call or it was predecisional with no details.

So, please, could you enlighten me a little bit about the process and the people who were involved in making this decision?

Mr. BOLDEN. Congressman, I think you are aware that I cannot discuss the pre-decisional discussions that we had, but I can tell you that the President's decision with this as with everything are iterative in the process, and I was a member of those who advised the President in the formulation of his budget.

So I am the one that represented NASA in providing information and counsel to the President in arriving at this budget, and once that decision was made, it became my budget. So it is my budget.

Mr. OLSON. Yes, sir. Again, it is very important to me that you were included in that, because you are the head of NASA, and again, as I told you, representing the Johnson Space Center, you have lived there, you live there still, you know, the Grayswell. I am not going to get in trouble with my colleagues here, but the manned spaceflight, and you know, we have got—nobody there had any idea what happened. They picked up and read the paper like I did on February 1, Monday morning, and——

[2] Page 22, line 465, of the transcript (see Appendix 2: Additional Material for the Record).

Mr. BOLDEN. Congressman, I can assure you, you know, once again, as I said, it was an iterative process. Every time I requested a meeting with anybody else involved, I got it. I met with the President personally, so this is my budget, and it results from the consultation that I contributed to the President's decision.

Mr. OLSON. Appreciate that. Further question for you, sir.

I would like to refer you to the report of the Aerospace Safety Advisory Panel, their report from 2009, and let me read a quote from the report. It states, "to abandon the Ares I as a baseline vehicle for alternative without demonstrated capability nor proven superiority or even the equivalent is unwise and probably not cost effective."

As you know——

Mr. BOLDEN. Yes, sir. I——

Mr. OLSON. —your name is on this report.

Mr. BOLDEN. My name is in that because I used to be a member of the Aerospace Safety Advisory Panel.

Mr. OLSON. You betcha, but given this new budget I want to ask you now do you disavow all of this, part of this, or none of it?

Mr. BOLDEN. I don't disavow any of it. I support, and I respect the opinions offered by the Aerospace Safety Advisory Panel. I consider them valuable counsel. I consult with Vice Admiral Dyer frequently because I know that we will sometimes have differences of opinion, but he is a much wiser person that I because he is older than I am.

But I do not take issue with anything that they presented. It is just that in the process of decision making sometimes we agree to disagree.

Mr. OLSON. Appreciate that, sir, and just to follow up again on one of the Chairman's comments. What is the backup if the commercial companies fail to deliver or go bankrupt or somehow can't perform? How do we protect the taxpayer dollars from those situations?

Mr. BOLDEN. Congressman, the backup is actually—puts us in a better situation than we would have been with Constellation. If we had gone through with the Constellation Program, we would have one system. We would have one vehicle for going into low earth orbit, and that was going to be Ares I. We would have had one vehicle to go beyond low Earth orbit. That would have been Ares V.

As it is right now I have two companies that are bidding on or competing for—to handle access to low Earth orbit. I am hopeful that both of them will successful. We are also intending to go out and reopen the competition to see if we can add even more companies into the mix. So conceivably there could be multiple companies that we recognize as having met the safety criteria for what we want to do, and then we are much better off than we would have been with a NASA design and built system in a single Ares I.

Mr. OLSON. Thank you for your comment, Mr. Administrator. I am sorry to cut you off. Got a little bit of time here, and I want to ask one more question or make sure you are aware of a situation I am hearing about back home.

There was a statement made by a very senior political appointee in the NASA front office, Mr. Alan Ladwig. It has been reported

on Twitter, and here is what he said. "For those who fuss over President Obama's budget for NASA, I have two words; bite me."

Bite me. I mean, that is one hell of a message to send to thousands of loyal NASA employees and contractors who have given their life to human spaceflight, and you know, according to our committee staff here, I mean, this outrageous statement was made while he was in a speech, while he was overseas for an audience in Strasburg, France.

And I think I know the answer, but I just want to make sure. Is this NASA's budget message to the American people and to our international partners? Bite me?

Mr. BOLDEN. Congressman, I was not aware of any statement of that nature, and I think you know that I would never tolerate that, and I would—rather than make any comment about it without, you know, finding out its validity, I would just say that is unacceptable.

Mr. OLSON. I appreciate those comments. We will get you the information you need.

Mr. BOLDEN. Oh, I will get the information.

Mr. OLSON. That is the Marine Corps general I love. Thank you, Mr. Chairman. Yield back my time.

Chairman GORDON. Thank you, Mr. Olson.

Mr. Costello is recognized.

Mr. COSTELLO. Mr. Chairman, thank you, and Administrator Bolden, thank you for being here today, and I thank the Chairman for calling this hearing.

Administrator Bolden, I have major concerns as well about the administration's plan to terminate the Constellation Program. As you know, we have invested over $9 billion over the last four years in this program. My concerns are many, and they involve costs of this action, not only in terms of cost in terms of money but also what the action will do to weaken our science and engineering workforce here in the United States.

The loss of jobs and how it will affect our economy, the loss of—my concerns about safety as to how it will affect the safety of our—those who participate in the program, and also the impact on national security.

As you know, the United States, Russia, Europe, Japan, and China have all been—their space programs have all been government-funded programs. If, in fact, the private sector could create a successful space program, I think they would have done so by now, either here in the United States or elsewhere. So these are a few of my concerns.

I happen to agree with Senator Bill Nelson. I don't think that we can do this on the cheap, and in fact, I think we could point to many programs in the Department of Defense, Department of Homeland Security, and other agencies of the Federal Government where we have outsourced functions that used to be the function of the Federal Government, and it, in fact, has cost the taxpayers more when we look at the cost overruns and some of the other issues that we have dealt with, both in Iraq, Afghanistan, and other contractors that have been hired to perform government functions.

So I want you to take that back to the administration. They are going to hear that not only from me, they are going to hear it from,

I think, the appropriators and others. So I have major concerns with going down this path.

I do have a couple of questions on my other hat as chairman of the Aviation Subcommittee of Transportation concerning two issues; one NextGen, and the other issue is just held a hearing yesterday on icing. As you know, we had a number—one commercial tragedy concerning icing about 13 years ago and a number in general aviation issues. So my concern is that we have seen over the past few years a decline in funding since fiscal year 2005. I wonder if—will aircraft icing on the side of R&D, which, of course, involves NASA, be a priority for NASA in fiscal year 2011?

Mr. BOLDEN. Congressman, I can assure you that when you look at icing and other issues that have not been funded before, the Glenn Research Center is the home of the largest icing simulation facility that we have. We—one of the things that we are also going to increase spending on is research into rotary wing issues. Rotary wing also has a problem with icing but even more importantly, we are beginning to look at issues of noise pollution, so we are looking for quieter rotor blades so that the increase in the aeronautics budget will enable us to do much more than we have been doing in the past.

You mentioned NextGen. We are actually increasing the spending that we are putting forward on NextGen because we really believe in it. We think it is critical for the Nation. One of the biggest champions of NextGen right now is the Secretary of Homeland Security, Secretary Janet Napolitano, in an Executive Committee meeting on NextGen that I attended with her, she was the number one spokesperson saying that if we didn't bring this program online very soon, that she was going to be in trouble, because it—NextGen is going to enable us to get people from the curbside safely in the air to their destinations, back to their baggage and back home, and it is critical that we do that. So we are increasing the amount of money that we are going to spend on the Next Generation Air Transportation System.

Mr. COSTELLO. We heard testimony yesterday concerning the icing hearing that enough research, some research has been done but maybe not enough coming from NASA, so I would just ask you to make it a priority. We need to do rulemaking and to move forward so that we can make certain that pilots who are not only on the ground but in the air, that they have adequate information concerning icing, training, and know what to do when they get into icing conditions, not only when they leave the ground but in the air.

Also on—my final question is about NextGen. Do you believe that you have adequate funds to move forward with the Next Generation Air Traffic Control System in this fiscal year budget proposal?

Mr. BOLDEN. Congressman, there are never enough funds to do what I want to do with NextGen. You know, some of it is if you gave me all the money in the world, I couldn't get you there any quicker because of technological issues that we face. Some of the problems with NextGen don't have anything to do with funding at all on the part of NASA. They have to do with getting buy-in from the business and the general aviation community because they are a huge portion of the airspace users, and pricing of the equipment

needed for the heart and soul of the NextGen system is something that we see resistance from the business and general aviation communities because they contend that the commercial guys don't have to worry about it. They just raise the price of the ticket. I am not sure that that is true, but that is their contention.

So I am confident that we have sufficient funds for this year and the out years to help us bring into play those systems that are necessary for NextGen. We will have to continue working, though, with the various segments of the user communities to see that we get them to buy the equipment that will be necessary to make this system effective.

Mr. COSTELLO. Finally, let me make the point that the Joint Planning and Development Organization, that is JPDO as you know it, NASA is very involved with them. I would encourage you to continue to make certain that you cooperate closely because the only way this is going to get done is through a cooperative effort with all of the Federal agencies involved. Thank you.

Mr. BOLDEN. I guarantee you we will do that. Even when I—before coming to this job when I served on an advisory council for the NASA, for the FAA Administrator, then I observed that NASA was a very strong member of the NextGen team, and since I have arrived as the Administrator, I have put extra emphasis on it. So I think you can be guaranteed that we are going to continue to push as hard as we can for the delivery of this system.

Mr. COSTELLO. Thank you, and thank you, Mr. Chairman.

Chairman GORDON. Sure. Mr. Rohrabacher is recognized.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman. Let me identify myself with the remarks of my colleague concerning air traffic control and icing type of research. I think that quite often that job that NASA has has not got the focus, and people don't get the PR or the publicity that human spaceflight gets, but those are vitally important to the safety and security of our—of the American people. And that is your job, and General, welcome aboard.

It is pleasant to hear that you do accept criticism, and I appreciate the fact that you have——

Mr. BOLDEN. I am married.

Mr. ROHRABACHER. There you go.

Mr. BOLDEN. And I have been for 42 years.

Mr. ROHRABACHER. Well, some people have had—some people get up here, and they get a little bit——

Mr. BOLDEN. To the same wife by the way.

Mr. ROHRABACHER. Good for you. God bless you. But some people don't acknowledge criticism or they just feel uncomfortable. You met that head-on where you have been criticized that your people briefed journalists before they briefed Members of Congress who are on the committee of jurisdiction. I am glad to hear that you have taken that seriously and will make sure that doesn't happen again.

Some of the—let me just note that NASA can't do everything, and if we are going to do these things like we just mentioned, air traffic control and research into icing to help protect people, we can't have programs that have $9 billion that are behind schedule, way behind schedule, and over budget and just ignore it and let it go on until you end up with a $50 billion program that is behind

schedule and over budget and may not be able to reach its goals. Sometimes you have to make decisions.

I will just have to say that I appreciate the fact that this administration and that you as leader in this area have decided to make some decisions. That fits with a Marine general I might add. You were in the Marines?

Mr. BOLDEN. Yes, sir. I am a Marine.

Mr. ROHRABACHER. You know, my dad was a lieutenant colonel in the Marines, and he would just roll over in his grave if he didn't think that I was calling you general and sir and the rest of it, but congratulations, General, for making decisions. In the Marines they say, the worst decision is no decision.

Mr. BOLDEN. No decision. Yes, sir.

Mr. ROHRABACHER. And I think that you should proceed in the rest of your responsibilities with that in mind.

Let me just note that some of the criticism that I hear of the decision that has been made here in Constellation that the primary consideration behind that criticism seems to be not safety and not necessarily human spaceflight, because we are not talking about human spaceflight but being accomplished in a different way. But instead in maintaining NASA's workforce.

Now, NASA, maintaining NASA's workforce, just to maintain the workforce is an expensive proposition, and if maintaining a workforce that is not meeting its responsibility, it is not on time, not doing things on schedule, not getting this thing to a place where we are going to accomplish specific missions, then that workforce is holding America back. And I can see whether it was the Space Shuttle Program or many other programs that I have been witnessing here in the last 20 years that maintaining the NASA workforce becomes a goal in and of itself. We have got to break ourselves from that type of thinking, or we are not going to be the leading power in space, and we should be.

I happen to believe that some of the criticism I have heard just totally disregards the fact that we have got private sector companies that have invested a lot of money in space and been very successful, and we now, I mean, we have the Atlas Program, we have the Delta Systems. I mean, these are very, very efficient and effective space transportation systems.

Now, correct me if I am wrong, but isn't it your plan, your proposal, to instead of going to this Constellation, which as you say would put all our eggs in one basket, isn't that to expand upon private sector and diversified sources to meet our obligations in low Earth orbit and delivering supplies and people to the Space Station?

Mr. BOLDEN. Congressman, that would be our hope, and you have pointed out something that we probably have not done a very good job of getting to the public and to Members of the Congress. Commercial—the way I define commercial, it is the aerospace industry.

Mr. ROHRABACHER. Sure.

Mr. BOLDEN. Some people define commercial as entrepreneurial, and they think that that is the only people that we are talking about here.

Mr. ROHRABACHER. We are talking about——

Mr. BOLDEN. But when we started out——

Mr. ROHRABACHER. Yeah.

Mr. BOLDEN. —with—and it started before my administration. Actually, Administrator Griffin was the one that began the COTS Program. When they started out, the only bidders happened to be entrepreneurial firms or smaller firms, and it, again, it is because the larger firms chose not to bid. We are going to, you know, open another round of bidding, and it is my hope that we will have some of the more experience aerospace companies who will decide that they, too, want to bid on——

Mr. ROHRABACHER. General, my time is about up. Let me just say that we need to encourage large companies, Boeing, Lockheed, Northrop, and the rest of these companies, we need to encourage them to be more entrepreneurial, and we need them—and that, I believe that is part of your plan, and but we also need to encourage those entrepreneurs who may become big companies in the future, and we want to wish them success, but I don't believe that the criticism that is saying that the decision being made has put us at risk of not having a human spaceflight capacity for the United States of America, I don't believe that is justified. I don't believe that it places the type of faith in big companies like Boeing and Lockheed, who have developed many technologies in the aerospace. In the history of aerospace they have done tremendous work, and we should be concerned about that rather than focused on maintaining the NASA workforce and read that NASA bureaucracy.

So thank you very much, and looking forward to working with you, General.

Chairman GORDON. Mr. Wu is recognized.

Mr. WU. Thank you very much, Mr. Chairman, and thank you, Administrator Bolden, for your service to our Nation as a Marine, as an astronaut, and now as Administrator of NASA, where I believe that you continue to be a good, loyal soldier and doing your job as best you know how.

Let me express my concern about the possible downside effects of this administration's decision. We are optimists by nature and especially those technologists who work in space. So the administration has on its side the rhetoric of the market and private sector and competition. The administration will at least initially have the benefit of technologists who look optimistically to the future.

I think it is incumbent upon those of us who at least for some time have seen the political sector work to be concerned about the potential downside analysis of what happens after a few years if this administration's proposal is accepted by this Congress.

We have a Constellation Program, which is not working out in an ideal way, but it is a public program, funded in the ways that every human spaceflight program thus far has been funded, because achieving Earth orbit is fundamentally different from a—the ballistic ventures that private companies have been able to do, at least at the very beginning.

The problem is that right now we are terminating or proposing to terminate Ares I because it is over cost. Now, we can discuss the flawed technology all that we want, but it is what we are committed to, and now we are going to put our—all our eggs in the private sector basket, and there are basically three contractors right

now; it is Lockheed-Martin, Boeing, and Space X. And they have the Atlas, the Delta IV, and a proposed Falcon IX.

It looks good right now to privatize, but this is the easy part. This is just the privatizational step. In 3, 4, five years, maybe 5 or six years when we really hit the hard part of getting those launch vehicles human rated, I suspect that we might have some of the same cost problems that public launch vehicles have had and that Ares I has, and if we do, it seems to me that the way Washington, DC, and the public decision-making process works is that we will then terminate the commercial spaceflight program because of exorbitant costs given to us by the private sector, just as the public sector has run into cost problems.

This is—the cost problems are to be anticipated. If you can cite a single satellite program that has come in on budget, I would be very interested to hear about that. So space—the costs go up because it is hard, and NASA's job is to do the hard things. I think one of the fundamental flaws of Ares was the decision to do something that was off the shelf because NASA should be in the business of making new technology and pushing our economy and pushing our—and pushing the envelope.

Computer science wouldn't be where it is without NASA's push for better ways to do things in the 1960s. I think that material science made a lot of progress because of the 1970s and the Space Shuttle, and our experience in putting astronauts in space for a longer period of time has paid great benefits. These are benefits to the American people, these are benefits to the human race.

If my sort of downside analysis works out, what is at stake? What is fundamentally at stake is whether future generations of astronauts speak English or speak Chinese, and I am an advocate that at least English be the lead language in human spaceflight. I was against privatization in the Bush Administration, I am against privatization in the Obama Administration.

I think that you all are running a huge risk, and I don't want to see human spaceflight, at least by Americans and the 17-nation consortium, which is counting on us, to be tubed and to have human spaceflight go to the Chinese or to the Indians.

And Mr. Chairman, let me just take one moment to express my concern. I got a call from a Canadian reporter. I call a call from a Canadian reporter about this topic, and I thought, golly, I mean, I expected a call from a Florida reporter. I don't expect calls from Oregon reporters because, you know, our connection with space are the astronauts that I bring for space camp announcements, scholarship announcements every spring.

But the Canadian made it really clear that if we don't fly, Canadians don't fly, and this is true of a number of other nations. They are depending on us, the American public is depending on us. We have failed on the mission of pushing technology with the current Ares I, but that is something we can fix, and if we privatize this, we are still going to need a labor force, and if you think that we are going to be able to afford three separate contractors for human spaceflight, I would like to see your business plan. I would like to—my apologies. Not yours. I would like to see the administration's business plan, because, you know, there is the business of lifting satellites up, but I don't think there is a workable business plan

for lifting humans up into low Earth orbit, at least, you know, from my business—it just doesn't look like it pencils out, and that is why we subside with tax dollars, and we can either do it directly to NASA, or we can give the money to Boeing, the Lockheed-Martin, or to Space X.

And I just want to note that to date they haven't launched a human being. We talk about airlines in space. Well, if—when we encouraged airlines after World War II, that was the right time. If we had encouraged airlines in 1910, before World War I, it would have been significantly premature, and I would encourage the Administration and your agency to consider whether this is premature, whether this is wise, and whether this dooms us to a future where there are no Americans in space or at least that the dominant language in space is not English.

Chairman GORDON. Thank you, Mr. Wu, and the unopposed Mr. McCaul is recognized.

Mr. MCCAUL. Thank you, Mr. Chairman, and I will allow you to answer—I am going to echo my colleagues, Mr. Wu and Mr. Olson.

Like Mr. Olson in my district I have many NASA employees and contractors at the Johnson Space Center. You know, since the inception of NASA, the mission has always been human spaceflight. You know, President Kennedy talked about landing a man on the moon, bring him safely back to the Earth. President Johnson carried that vision on. The goal was met, and I am concerned about the mission changing.

I am concerned about the human spaceflight mission being completely cut out of this budget, the Constellation Program going away, and an increase in funding towards something that I don't consider to be a core mission of NASA, and that is climate change and weather observation.

It seems to me we are getting away from the core mission of NASA. We are getting away from the national security aspects that NASA has always played that we know was vitally important to our space race against the Soviets back in the '60s. I think as Mr. Wu mentioned, the language, I hope it does continue to be English, but I think the Chinese and Russians could overtake us.

I don't—you know, commercial space developers I don't believe are at the point where they can take over this program. We have already spent—we have invested $9 billion in the Constellation Program. It will take another $2.5 billion to terminate. That is $11.5 billion invested in the Constellation Program, and now we are just pulling the rug out from underneath that program. I think we are sending a message in terms of the mission that is not a positive one, and that is human spaceflight is not the priority anymore but rather climate change and weather observation.

I know you spend a lot of time at the Johnson Space Center, and I really respect your service and thank you for your service as Administrator, but I find it hard to believe that you actually agreed with the President's decision here. Now, I know you have to carry out his orders. You are in the chain of command, but I question whether you do agree with this, having the experience that you have had at the Johnson Space Center.

So if you would just care to comment to me on—and I know you won't be able to answer, maybe you can, whether you really do agree with this decision.

Mr. BOLDEN. I can answer.

Mr. MCCAUL. And how possibly commercial space developers can pick up the slack, particularly after we have invested so much money in the Constellation Program.

Mr. BOLDEN. Congressman, I do agree with the decision. I think it is possible, and in fact, I will try not to take too much time, but I will take some of us back to the 1980s when I first came into the astronaut office. We had not long flown the STS I, II, and III. We had gotten into the Space Shuttle Program, and it became apparent to us that if we continued, if NASA continued to try to operate the Shuttle, that is all we were going to do.

And we actually started looking for commercial entities that would be willing to come in and take over operations of the Shuttle, much the same as we are trying to do today with the new commercial program. And there were companies like United Airlines, Lockheed, Boeing, American Airlines that all were going to bid on the operations contract for the Space Shuttle, to offload that.

We even participated in providing training manuals to them for crews and the like, and then something happened called *Challenger*, and in 1986, January of 1986, when we lost the *Challenger*, all efforts at outsourcing, if you will, because that is what it would have been at the time, outsourcing the operation of the Shuttle went away.

The Air Force was going to take over the responsibility for conducting classified missions, which NASA, some of you will remember, NASA flew all of the human classified missions up until 1986. January of 1986, January 28, 1986, the world changed. President Reagan decided that it was not smart to put satellites on the Space Shuttle, you know. They did not feel it was worth the risk to put an astronaut and a satellite in the same vehicle, and we stopped deploying satellites.

So the world changed on January 28, 1986, and things that we are trying to do today we were trying to do then, and I think they would have been successful had it not been for the *Challenger* accident, and I don't make light of anything, but I tell people all the time, the trauma of the loss of *Challenger* to this Nation and the world, we are still suffering.

Mr. MCCAUL. And General, with all due respect, I've got 15 seconds. I want to throw this last question out to you, and that is I think NASA, the program has been one of the best investments of Federal dollars that we have had, the model success, the return on investment. What are we to tell our constituents? What are we to tell the people at the Johnson Space Center in Houston, Texas, Clear Lake, the people that you know so well. Mr. Olson and myself, when we go back home, what impact is this going to have on them?

Mr. BOLDEN. The Johnson Space Center as well as the other NASA centers, we are going to do everything in our power to ensure that the programs that develop from this budget that are—that we are able to develop from this budget, from the increased money that we are going to have, are going to enable them to con-

tinue to do the type of work that they do. They are going to—there is always going to be need for engineering effort. There is always going to be a need for development, and we are, you know, I wish I could give you definitive programs that we are going to have now, but we are two weeks, three weeks after the rollout of the budget, and we have not gotten those types of answers.

But I promise you that within months, because I have asked for studies to be brought to me to help us determine which programs we are going to do. Within months we will be able to put some meat on the bones, if you will, because I realize there is a lack of detail, and that is disturbing to everybody. It is disquieting and discomforting to me, but we are going to get some answers for you. We will have some programs defined.

Mr. MCCAUL. Well, I think you are going to find there is going to be a lot of opposition in Congress to the cut of the Constellation Program. Mr. Chairman, I hope we can work together in the Congress on this issue. Thank you.

Chairman GORDON. You are absolutely right, Mr. McCaul, and we want to continue to talk through this in, you know, in a fair and reasonable way and better understand what, you know, will this new program work, you know, why do you make the changes. There is more discussion that needs to occur.

And to continue that discussion, the Chair of our Subcommittee on Space and Aviation, Ms. Giffords, is recognized.

Ms. GIFFORDS. Thank you, Mr. Chairman. Good morning, General Bolden.

There are many members here that don't have as much time with you, so I am going to try to keep my statement as pretty brief as possible and just wrap up with a question at the end.

On the positive side, there was a lot about the President's budget that we can be excited about. Unfortunately, our country has under-funded science, under-funded the investment into research that we all know is really important to those of us that sit on this Committee. And I think it was interesting to see in the President's budget proposal that there was a variety of funding streams that we are frankly really excited about.

As you have heard from my colleagues and you will continue to hear, there is serious, serious concerns about the President's decision to decimate our American human spaceflight program. By canceling the program of record, we trade a program that we know will work, although it has experienced delays and part of those delays, unfortunately, came from drastic under-funding, but it is a program that has been deemed as the safest program to take our astronauts back to lower Earth orbit and then back to the moon, Mars, or wherever we choose to explore.

My concern when considering the space program and the future is not one pet project over another, one state over another, one facility over another, one plan, one aerospace company over another. It is truly how do we best and most prudently use the taxpayers' dollars to achieve this great desire that we have sea, lands and Members of Congress as well have to explore. We want to get outside of lower Earth orbit. We want to really challenge the way that we understand science and space, and we want to move forward.

You are going to have a lot of questions that our subcommittee, Mr. Olson and I and members of our subcommittee, are going to be grappling with as we move forward with writing the authorization plan. Some of the things you are going to hear about, of course, is the workforce, and Mr. Rohrabacher is no longer here, but if you look at the tens of thousands of direct jobs that are going to be impacted with the sun setting of Shuttle and with the planned termination of Constellation. But, in fact, hundreds of thousands of highly-skilled jobs through subcontractors and indirect industries will be impacted if these decisions move forward as well. And we are going to be working to flush out those numbers so that every Member of Congress understands the impact to their employers and to their constituents.

We are also going to delve further into what is going to be happening with the production of the solid rocket motors. I mean, the decline in this industry when looking at our acquisition of strategic missiles, is something of great concern, and I serve on that House Armed Services Committee, and as I understand, Secretary Gates was not consulted and was not aware of the plan to terminate Constellation, which has a direct impact on our Nation's security.

We are also going to be delving into international competitiveness. A few months ago we had a hearing with a variety of experts. We heard from Mr. Houser of Space Foundation, who had recently returned from visiting—and I quote him here, he says, "In this past September a delegation led by the Space Foundation visited China and toured a number of previously-secret space facilities. It was a stunning experience. Not only are China's facilities newer than ours, they are state of art and in some ways downright luxurious compared to ours."

So as China continues to invest heavily, as the Russians continue to be steadfast in their commitment, and as we see other countries show an interest, I am very concerned and other members as well on what is going to happen with U.S. dominance in an area that we think is so important.

So my question to you knowing that these other questions are out there and we will continue to gather the information as we write our authorization bill, we were pretty surprised here at the United States Congress about this decision to terminate a program that the American people and Members of the Congress have invested tremendously in, not just for the last couple of years and the last 10, 11, $12 billion in Constellation, but for 50 years, in fact, so can you please talk, General Bolden, about who was consulted, how you went about this decision, who did you reach out to, who did you bring in to make a radical decision like this to terminate our United States human spaceflight program?

Mr. BOLDEN. Madam Congresswoman, I can explain that I brought in all of my senior leaders from the time that I began the Administrator we had strategic planning meetings dealing with the fact that I was going to have to make a recommendation to the President. So we met for months to formulate a position that I took. I consulted with the President, and as far as what the discussion was, again, I have to go back to the fact that it is all predecisional, and I am not at liberty to share that.

But I played an integral part in the decision that the President made, and once that decision was made, then the budget became mine. So this is my program, it is my budget, and I, you know, I can't say that too many times. I wish I could blame it on somebody else if somebody needs to take the blame, but I played an integral part in the process that arrived at the President's decision on where we are going. And I do agree with it.

Ms. GIFFORDS. Well, Mr. Chairman, General Bolden, certainly we understand as NASA Administrator that this is your plan. I am trying to make sure that everyone understands that, at least speaking for myself, that I very much wanted to see NASA successful, and I want to see the President successful, but that means the United States of America to be successful. And proposing a decimation of the most exciting project or program that the United States does without consulting with Members, without talking to the defense industry, without really building a coalition to make such a radical shift, is hard to stomach, and it is just something that, you know, we are going to have to work through because there is deep, deep concern among the subcommittee members, Democrats and Republicans. I mean, this is a very strong bipartisan concern that we have with what was proposed by the President, and we want to work with you, we want to work with the President, but some of these, you know, what you are proposing in a four-page draft memo is just, it is too great of a shift to really not have those details when presented to us in the Congress.

So, Mr. Chairman, we are going to be working to get that information, and I thank you for the time.

Chairman GORDON. Thank you, Chair Giffords.

Before we proceed, let me just make a quick announcement to our friends that are visiting on the committee now. Our rules require that—we always try to alternate back and forth, but since there are more on the majority side here, they need to go through first, and then we will be happy to let you participate in any way you would like.

And so Ms. Fudge is recognized.

Ms. FUDGE. Thank you, Mr. Chairman, and thank you, Mr. Bolden. It is nice to see you again.

Mr. Bolden, just in my opinion the lack of a clear mission with goals and milestones fails to not only inspire the current NASA workforce but also fails to inspire the future generation of scientists and astronauts, something that is so critical at this point in American history, while we are talking about the need for more students to be excited about careers in STEM fields. Having no light at the end of the tunnel be it on Mars or the moon, we will not serve our country well at this time.

Just last week I was at JFK High School in my district where I was talking to a young ROTC student. I asked him what he wanted to be, and he said, an astronaut. I had no clue what to say to him at that point. I wanted to say to him, find something else to do because the chances of becoming an astronaut or a rocket scientist are approaching zero because NASA is canceling its human spaceflight plan.

I am confident that NASA Glenn can play a significant role in the technology development programs you have described and look

forward to learning about Glenn's part in the new programs. But clearly these are important priorities that support that mission of NASA, but the idea of technology development alone without a corresponding flight plan may not be sustainable.

We have seen this before in NASA's recent history. In 2003, Project Prometheus was a technology development program to create nuclear power and propulsion technologies. Then NASA administration Sean O'Keefe—Administrator Mr. O'Keefe stated that the objective of the program was to hone technologies that would allow the agency to fly any number of destinations that are possible, which sounds quite similar to what we are hearing today. After two years and $464 million, Project Prometheus was canceled due to a shifting of agency priorities at a top-line budget number that squeezed out many other programs.

Technology development programs are always vulnerable when not tied to a specific flight program. How can we be sure that these technology development initiatives will not meet the same fate, especially with no independent assessment of the end cost of supporting commercial crew transport development?

If these cost estimates rise, how can we know these technology development programs will not be sacrificed as they have in the past?

Mr. BOLDEN. Congresswoman, let me just quote something from the Augustine Committee report, the concluding observations, and for those of you who have it or have seen it, it is on page 111, and I found it interesting because Norm Augustine and I talked about this extensively during the course of the program. He said, "Planning a human spaceflight program should start with agreement about the goals to be accomplished by the program, that is agreement about its raison d'etre. Not about which objective in space to visit. Too often in the past planning the human spaceflight program has begun with where rather than why."

Norm and I talked extensively about it because as I did in the strategic planning sessions with my leadership, I said, you know, if we don't know why we are doing this, we may as well quit. My question to them was why do we even—why do humans need to go to space? We do need a destination. That destination ultimately is Mars. But we need to know why we are going there. We are going there because the human species is incredibly inquisitive. We think that there is potential for life on Mars or at least potential for people to be able to live there at some time, much more than any other planet in our solar system.

So that is the why that we came up with, but in direct answer to your question, you know, I was glad you did not tell the student not to think about being an astronaut. I would have told—and I assume it was a middle school student? High school?

Ms. FUDGE. High school.

Mr. BOLDEN. I would have told him forget it for awhile. I always do, and I would have told him, go back and study and make sure you graduate from high school, go to college, and then get an undergraduate technical degree as Congresswoman Edwards will probably tell you I always tell them.

So I am glad you did not tell him not——

Ms. FUDGE. But I want, I really want you to get to we have done something like this in the past. Because the cost became exorbitant, we just shifted and said we are not going to do anymore. How can you guarantee me that is not going to happen now?

Mr. BOLDEN. I can't guarantee you, but I can tell you that I am confident that the program that we are laying out based on the budget that we have will support and sustain our ability to get not only to low Earth orbit, to continue to get to low Earth orbit, but to go beyond low Earth orbit with a program once we develop a heavy-lift launch vehicle, that will get us to Mars, get us to the moon, get us to asteroids. It is critical that we do all these things.

While Mars is the ultimate goal, asteroids are pretty important, too, because they threaten the planet, and unless I know what they are made of, whether they are dirt or whether they are iron, I don't know what to advise the President on how to protect the plant from them. So I can see one day when the astronauts go to asteroids, because we don't understand them a lot. We were all awakened when Hubble gave us an image of the planet Jupiter late last year with this big black hole in it, a hole that was the size of several diameters of Earth. That was a wake-up call.

So there are a lot of reasons that we need to send humans to space that are different from what they were September of last year. We learn something new every day about why we need to be exploring space, and the program that we have now, particularly because we have sufficient funding research and development makes it different from when we were trying to do Prometheus. We were probably down to zero in the money that NASA sent to colleges and universities around the country for technical research and development. I think you will agree with that. You know, Wilberforce or any other college in your area probably got nothing from NASA for research and development.

This budget allows us to start putting money back on college campuses so that kids will be excited about wanting to go study with a professor who is working on a project, a research project for NASA. That wouldn't happen last year. So things are different, and that is why I am confident that this is going to work.

Ms. FUDGE. But, again, you can't tell me that in another year or two or three we may just change and shift gears again.

Mr. BOLDEN. Congresswoman, I can't tell you, you know, in our system of government there are good things about our system of government, and there is one horrible thing about our system of government, and that is it changes every four years and with it ideas change.

And so I can't guarantee that President Obama, if he is reelected, or the new President if he is not reelected, will have the same vision that the President presently has. I can tell you that as long as President Obama is sitting where he is and I am sitting where I am, we are focused on increasing the research and development that is done in industry and academia. We are focused on getting kids to the point where they become proficient in STEM courses so that we don't lose the battle of intellect to the Chinese or the Russians or the Indians or anyone else.

We have a very—we have a shared vision, and I, you know, people tell me I don't know what the President wants to do. I do know

what the President wants to do. I have sat with him. I know how much STEM education, how important it is to him and how much inspiring kids is to him, and we did not frivolously arrive at this budget.

Ms. FUDGE. Thank you.

Chairman GORDON. Thank you, Mr. Bolden, and Ms. Edwards is recognized.

Ms. EDWARDS. Thank you, Administrator Bolden, for your testimony today and for being here.

I want to say, I mean, I, like many of my colleagues, have just been floored by this proposal, and I think part of the reason is jumping off the point where you ended, about inspiration. I think one of the things that inspires young people to get engaged in science, to be interested in space is the inspiration that has actually been created really through the human spaceflight program. And so it is—I am struggling trying to figure out how in this budget we derive that inspiration for the future.

But I want to go to some specific details. One is, you know, I could be really concerned, not as concerned about this budget because truth be told, Goddard Spaceflight Center, which is in my—in the county in which I live and a lot of the folks who work at Goddard are my constituents, and you know what? We win big in this budget, but the fact of the matter is that this is really about a vision for our space program, and our space program is a three-leg stool. It is the Earth sciences in which we engage, it is the research and development and technology development, but it is also human exploration, and I feel that this budget, with this budget we lose one of those legs of that stool.

And so I want to ask you actually about the commercial sector, and I will just quote for a minute from Anatoly Perminov of the head of the Russian Space Agency, and he said, "We have an agreement until 2012 that Russia will be responsible for this about carrying astronauts from other countries into low Earth orbit, but after that, excuse me, but the prices should be absolutely different then."

What is it about in terms of the administration and your confidence in the commercial sector that enables you to believe that after 2012, we will have a robust commercial sector that is really able to deliver on its promises? Because if you look at the—what has been expended to date, I want to know what hardware has been delivered from the $618 million that has gone out. What services have been provided? What does NASA own? Where are the intellectual property rights, and what has actually been tested and worked to give us that kind of confidence that after 2012, we won't just be floating more and more money into this, having lost 9 and then 3 billion, $12 billion out of where we have been?

I just—I really don't get it, and I would say lastly that just in terms of risk, the commercial sector is never going to absorb the kind of risk that it really takes to get these vehicles off the ground, and at the end of the day the taxpayer will always have to absorb that risk, and if that is true, then why not really take it on by continuing to have NASA fully engaged in human spaceflight? Because when it is all said and done, it is going to be on us anyway.

And I want to correct for the record Mr. Rohrabacher because the reality is that the job loss that we are talking about in this workforce is a private sector workforce. It is a technical, skilled, scientific, scientifically capable workforce that is a private sector workforce. This isn't just about retaining government jobs.

Thank you.

Mr. BOLDEN. Congresswoman, I think you asked me a question, and I am going to try to remember it and answer it for you. However, I want to thank you for the comment in response to Congressman Rohrabacher's because I didn't—he didn't ask me a question, so I didn't get a chance to comment on it. It is more than just jobs. We are talking about people who have incredible qualifications and capabilities, and so I share everyone's concern about the workforce, about retaining the workforce. I have had conversations with some of you. You know, it is my intent that this budget will allow us to try to find ways to cross train our people, to help bring them into the 21st century workforce where, you know, a person who is—who can turn a wrench or hammer a nail or whatever else it is, there are very few jobs like that in the space industry anymore, and we have got to transition the workforce.

We were going to see a bucket in terms of job losses at the termination of the Shuttle Program. We knew that. What has kind of thrown us a curveball is that a number of those people, not all of them, were going to have gone to the Constellation Program. We are working feverishly now and will be working over the coming months to come up with follow-on programs that are going to replace the Constellation Program to ensure that we can get humans beyond low Earth orbit, to ensure that we maintain the ability to get humans into low Earth orbit by American-manufactured rockets. And we are going to do that.

Ms. EDWARDS. But, Mr. Bolden, what gives you the confidence in this program given that they are already behind schedule, they are already under budget, and they haven't delivered anything yet?

Mr. BOLDEN. I have not—I mean, you have information I don't have, Congresswoman. I, you know, we have milestones for Orbital and for Space X to meet, and to date I have not been informed that anyone has missed a milestone. We are—as far as I know, Space X, because I visited their launch complex 40 facility and looked at their rocket and talked to their engineers two weeks ago when I was down for the STS–130 launch, and they were very optimistic that they were going to launch here in a month or so. Their first flight.

Now, they don't launch for us until 2011. They are—we will be their third flight, so they have milestones that they have to meet, and until they fail to meet a milestone, I can't say that they are behind. You know, we pay them based on their meeting milestones, and so far we have not failed to pay them because they have not failed to meet a milestone.

Orbital is a very proven company when it comes to putting things in space. Putting people in space is a new deal for them. Boeing, Lockheed, USA, ATK, these are all well-established companies, and they have an opportunity to bid in the next round for commercial, you know, for an opportunity to be a part of the commercial space program. And what makes me confident that it is

going to work is because these are experienced people who are dedicated to what they do, to human spaceflight.

As I told the employees at Marshall, they are being unfair when they criticize companies like Space X and Orbital and others because some of the people who are doing the jobs now were their former coworkers. You know, we are not talking about hobby shops. We are talking about very professional engineers in these commercial companies.

Chairman GORDON. Thank you.

Mr. BOLDEN. You know, that they can do what we ask them to do.

Chairman GORDON. Mr. Grayson is recognized.

Mr. GRAYSON. Thank you. What is our next destination for America in space?

Mr. BOLDEN. The next destination for America in space, and I am not being trite when I answer this, is the International Space Station. We have got to get there four more times this year. The big, the long-term destination after we successfully close out the Space Shuttle Program, the ultimate destination is Mars, and there are intermediate points that we are going to have to get to before we are capable of going to Mars.

If you gave me all the money in the Federal budget today, I could not get a human to Mars. I could not morally put a human in a spacecraft and launch them on an 8-month mission to Mars because I do not understand the radiation requirements——

Mr. GRAYSON. All right. So what is our next destination in space?

Mr. BOLDEN. The next ultimate destination is Mars.

Mr. GRAYSON. No. The next one.

Mr. BOLDEN. Congressman, the next destination as I said before is the International Space Station, and we got to do that four more times.

Mr. GRAYSON. All right. Let us not be trite then. What is the one after that?

Mr. BOLDEN. It is Mars.

Mr. GRAYSON. So there is nothing in-between as far as you are concerned?

Mr. BOLDEN. But there are intermediate stops——

Mr. GRAYSON. What are they?

Mr. BOLDEN. —on the way there.

Mr. GRAYSON. What is the next one?

Mr. BOLDEN. The moon is a destination, Lagrange points are destinations.

Mr. GRAYSON. Which one is next?

Mr. BOLDEN. You mean where do we go immediately next? Is that the question?

Mr. GRAYSON. That is what next means.

Mr. BOLDEN. Congressman, I—we are in the process of developing a program. I will have to be able to give you the details, and I will come back and make it for the record in the coming months.

Mr. GRAYSON. So why are we even talking about how to get to the next destination. We don't even know what that is.

Mr. BOLDEN. Congressman, we do know what it is. We know what——

Mr. GRAYSON. What is it?

Mr. BOLDEN. Congressman, I, you know, we can go back and forth forever.

Mr. GRAYSON. We seem to have to here. I am looking for an answer.

Mr. BOLDEN. Okay. The next destination in the Constellation Program was the moon.

Mr. GRAYSON. What about now since you are trying to eliminate that?

Mr. BOLDEN. Congressman, the program of record and the program to which we are working right now because you have told me that I have to continue to work the Constellation Program, you know, we are talking about the 2011 budget, but if you ask me right now, the next destination is the moon.

Mr. GRAYSON. Okay. Good. Now, the Augustine report came up with four options and several sub-options or alternatives within the options. Which one did the administration adopt?

Mr. BOLDEN. The administration adopted the recommendations of the Augustine report which is the flexible path.

Mr. GRAYSON. Which option?

Mr. BOLDEN. The flexible path.

Mr. GRAYSON. The flexible path?

Mr. BOLDEN. Yes, sir.

Mr. GRAYSON. Okay. So you think that——

Mr. BOLDEN. That was the recommendation of the Augustine Committee.

Mr. GRAYSON. All right. Now, you can correct me if I am wrong, but I did read the report, and it seemed to me that the flexible path involved continuing the Constellation Program. Is that a fair statement?

Mr. BOLDEN. The Constellation, you know, the Augustine Committee did not recommend cancellation of the Constellation Program.

Mr. GRAYSON. So then I am right.

Mr. BOLDEN. You are right that they did not recommend cancellation of the Constellation Program?

Mr. GRAYSON. The flexible path included continuation of the Constellation Program.

Mr. BOLDEN. The flexible path did not necessarily include—I think you are cherry picking from the report. The report said——

Mr. GRAYSON. I just want to know why you had all these people come together, the people who knew the most about the space program, and then you ignored their recommendation to continue the Constellation Program. That is what I am asking.

Mr. BOLDEN. Congressman, they did not recommend continuation of the Constellation Program. What they said——

Mr. GRAYSON. The flexible path did.

Mr. BOLDEN. Congressman, what the report said was that they find no technical challenges in the Constellation Program that cannot be met the way that NASA has always met them, however, to do so will cost a significant amount more than anyone will reasonably be able to place in a budget.

Mr. GRAYSON. Right. Regarding the budget, it seems to be your plan to put people in space through commercial programs. Is that correct?

Mr. BOLDEN. I intend to put people into low Earth orbit through commercial programs.

Mr. GRAYSON. How often has that happened so far?

Mr. BOLDEN. We do it today.

Mr. GRAYSON. Explain to me. Go ahead.

Mr. BOLDEN. Well, today I go out and I pay USA to operate the Space Shuttle out of the Kennedy Space Center. The vast majority of my workforce right now as Congresswoman Edwards mentioned, 89 percent of the workforce in the Shuttle Program today are contractors.

Mr. GRAYSON. So you consider the Space Shuttle Program to be a commercial program?

Mr. BOLDEN. I consider the Space Shuttle Program to be evidence that commercial entities can successfully operate——

Mr. GRAYSON. Would you just please answer the question. My time is limited.

Mr. BOLDEN. Yes.

Mr. GRAYSON. Okay. So what is wrong with continuing at that?

Mr. BOLDEN. We would not—I do not think it would be wise to continue the Space Shuttle Program beyond the four additional flights that we are on track to fly right now. I think that would not be prudent.

Mr. GRAYSON. But if one is commercial and the other is commercial, what is the advantage of switching?

Mr. BOLDEN. The advantage is that we relieve ourselves of the responsibility and the cost for operating and maintaining infrastructure as we do today with the Space Shuttle Program.

Mr. GRAYSON. Isn't it true that commercial entities have never put a man in orbit?

Mr. BOLDEN. Commercial entities have put every human in orbit that we, the United States has flown. If—and you can take that up with North American Rockwell or Boeing or the United Space Alliance.

Mr. GRAYSON. Honestly, I will tell you, my time is up now, so I am going to tell you this briefly. I think that what you are doing is taking a shot in the dark. You have no way of knowing if any commercial entity will ever be able to put a man in orbit, no matter how much money you throw at them. What you are doing is you are taking NASA's man space program and making it a faith-based initiative.

I yield the rest of my time.

Chairman GORDON. Ms. Kosmas, thank you for your patience and you are recognized.

Ms. KOSMAS. Thank you very much. Thank you, General Bolden. I want to first of all thank you for your service to our country, both in the military and as an astronaut for us. I want to hearken on a comment that was made yesterday by Dr. Holdren where to quote him, he wants to ensure that what we do continues America's leadership in space and science and assume that you would agree that that is a goal worthy of our attention.

Mr. BOLDEN. It is my intent. That is not a goal. That is—I am determined.

Ms. KOSMAS. Okay. That is good to hear. That is good to hear. I want to suggest to you also that inspiring generations is part of

the goal, I think, for the future, and I was glad to hear you say that from the balcony of the movie theatre in Columbia, South Carolina, to the commander's seat on a Shuttle launch into outer space, you had been inspired by the space program and have made—led a very inspirational life for all of us, and I am sure would like other to do it.

There are a number of things that I am extremely concerned about, many of which have already been covered by my colleagues. If I have to identify them in short order, I would say the job loss in my community, as you know, is devastating based on the impending finality of the Shuttle Program, if that, in fact, is reality, and the lack of specificity in the budget for what we will be doing next and what skills or knowledge will be required.

In the short term we will be losing a highly-skilled and competitive workforce from my community, one which is already suffering from 12 percent unemployment. We will lose, I believe, the opportunity that was given to you to be inspired by space because we don't have the specificity of the program. I think we are at risk of losing our leadership internationally as has been not only alluded to but expressed with great detail by others here today.

I think you referred to losing the battle of the intellect to other nations, and I think that is something that is very serious, a concern to us without having the inspiration that will provide for the next generation, for the 21st century jobs, the economy, the national security, all of which is contained in inspiring our next generation to move forward in fields related to obviously the STEM programs, and nothing does it better than manned space exploration.

There is no greater inspiration to those folks sitting around in a room developing something without any idea where it is going to go is not what I would call visionary or inspirational. We have had this discussion previously.

I am also concerned about our actual lack of access to the International Space Station. I am pleased that we have extended its life for five years, but the fact that we have no vehicle to get us there past the four Shuttle launches planned is of great concern to me, and so in outlining those things that are of specific concern to me, I want to ask you another couple of—or a couple of questions.

I think we all agree we want to maintain our access to the Space Station. There is no way we can actually maximize the additional five years unless we can get there. We have—as others have said, we have no proof that there is a commercial opportunity to get there.

I have asked before about the possibility of extending the Shuttle. I don't want to beat a dead horse, and I am not looking backward, but if we have extended the life of the Space Station and the Shuttle is the only vehicle that we have currently that is able to take us there for service, for support, for access of a wonderful resource that we have, can you tell me what it would cost us or can you respond to me about why it is that we have eliminated that as a possibility going forward?

Mr. BOLDEN. Congresswoman, there are a couple of reasons, and I will be happy to answer in detail for the record because I don't want to give you—I am going to give you some numbers that are

not precise. It costs us in the neighborhood of $2 billion a year to operate the Shuttle. That is a cost that would come out of other programs if we decided to extend it.

There is the issue of potentially having to recertify the vehicle, reopen——[3]

Ms. KOSMAS. I think that is done on sort of a recurring basis, and so those are things that we probably could discuss. Again, I will look forward to your response on that.

Again, the lack of specificity has been hit on so many times that I am not going to go there, but I think it is very essential that you provide us greater detail of what the research and development and so forth is going to be for—I know in the budget there is also—and we are pleased with this, $2 billion for upgrading the infrastructure. How do we go about being efficient and effective in upgrading infrastructure when we have no idea what the architecture we will be planning for is going to be?

And that is a question that is, like I said, that is a thank you for the money, but how are we going to use it effectively if we do not know what the architecture——

Mr. BOLDEN. We have actually been involved in discussions with the Air Force, particularly a 45th space wing for a number of years, about range upgrades that they want to do, and we now have funds that will allow us to do things on our side that will enhance their ability to do the range upgrades.

Ms. KOSMAS. Okay. Well, I would look forward to having more detail with you about not just what has happening at the 45th but also at Kennedy Space Center——

Mr. BOLDEN. Yes, ma'am.

Ms. KOSMAS. —and how we manage to maximize that for the people of my district, who are looking to lose their jobs and add to an already dire situation. So we—I would look forward to hearing more from you in that regard.

I just am also concerned about the cancellation of contracts as has been discussed by others and hope to hear more from you on that. I think there are many of us who feel that Congress should have the opportunity to respond as a body to the budget proposed by the President and that cancellation of contracts at this stage of the game before Congress has engaged in what our alternative proposals might be is premature and puts my workforce, my highly-skilled and professional, valuable workforce at even greater risk as they were depending upon some of these contracts moving forward during the transition period.

Mr. BOLDEN. And Congressman, I think hopefully I was clear when I sent my letter back that we have not directed any contract cancellations, nor is it my intent to do that. I intend to be in full compliance with the law in the form of the 2010——

Ms. KOSMAS. But even cancellations——

Mr. BOLDEN. —appropriations.

Ms. KOSMAS. —to the future of 2011, has the impact of making decisions without Congress having weighed in on your plan.

Mr. BOLDEN. And our intention is to, as I told the Chairman before we came in, our intention is to be in full and complete delib-

[3] Page 72, line 1703, of the transcript (see Appendix 2: Additional Material for the Record).

eration with you in the coming weeks and months about where we go. Congress will be—you will be an important part of the deliberation.

Chairman GORDON. Thank you, Mr. Administrator.

Ms. KOSMAS. Thank you.

Chairman GORDON. And, Ms. Kosmas, I think part of your discussion points out to whatever happens needs to be determined soon with some certainty. There will be probably more jobs not lost than will be lost, but if you don't know where you stand in all that, it is very difficult. And so we have got to bring some certainty to this, both for the expertise and the human aspect of it, as well as to get the best program before us.

My neighbor from Tennessee is recognized, Mr. Davis.

Mr. DAVIS. Mr. Chairman, thank you very much, and thanks for holding this budget hearing today. I know that the process sure is that we would basically in this Committee authorize certain expenditures as we go through this budget process, and that is the reason a lot of us are here today and perhaps many have some questions to ask.

I will relate to you some experiences, and Bart will probably chastise me for doing this, we often have in rural areas growing up, wherever it may be, and my situation in rural Tennessee. I look at this budget and realize there is $19 billion, that is about a 1.5 percent increase, but you will be making a cut to a complete program of Constellation.

I know that in the mid '50s Sputnik kind of startled us. In the early '60s John Kennedy made a statement that we will send a man to the moon and return them within this decade, and on July the 20th, 1969, the world also saw space change, because we landed a man on the moon, and I sat at Camp Boxville in Bart Gordon's district near Gallatin, with about 25 Boy Scouts of which I was a Scout Master. We watched that happen. It was unbelievable, and so the world changed then, too, when it came to space, but we have made some pretty strong commitments to make that happen.

I know that 1986, as I sat at my house and watched with my teacher wife the *Challenger* blow up, yes, there is no question that also changed the way we look at space and the dangers of it, but are we again looking at a change that will be as devastating to us as the 1986 accident was, or are we making a decision that will make us another July the 20th, 1969? I don't know which place I fall there.

And here is why. When I would go to Tennessee Tech to get a degree where I became a soil scientist, I would often hitchhike from Cookwood to Pall Mall. There were times people would be going all the way to that area, and I could get a good, safe ride there. I want to be certain that we will continue to have space vehicles and a safe space vehicle that will allow us to get to Mars. I don't want us sitting on a star in the Constellation, hitchhiking with China or Russia to arrive at that destination.

Because my fear is if we don't head in the right direction, that we will not have a vessel or spaceflight, and we will have to fly with someone else, and this country cannot afford that, nor should we put ourselves in that position.

I also realized that one day driving up the mountain where I live, as I reached a higher elevation, I assumed the road was still wet. It was black ice, and I crashed. Are we headed on the collision course as we cancel Constellation and look at private entrepreneurs, and there is no—when we talk about private entrepreneurs, let us make something perfectly clear to everyone in this room.

Outside a situation in Oakridge, Tennessee, where 12,000 people work and 400 work for the Federal Government, the rest work for private entrepreneurs funded by the Federal Government or the taxpayers. We are still going to be funding at a level, maybe with less direction, from my perspective.

So here is the question. Ten years from now in your perspective as you went through this process, ten years from now what percent would you say of completing our objectives could we have with the Constellation Program or with the new process that you are taking? Which one has us more certainty, and what percentage can we expect of success with Constellation compared to the steps that you are taking in this new budget?

Mr. BOLDEN. Congressman, if I go with the report of the Augustine Committee, ten years from now we would definitely not be on our way to the moon because that report said that we were sufficiently behind both in terms of progress on completion of the vehicles and everything. So we would not be where I think we may be on the path that we are set in—that is supported by the 2011 budget. It is my hope that by 2015, 2016, we will have an American capability at work getting humans back to low Earth orbit, to the International Space Station, perhaps more than just one as we would have had with Ares I. And it is my hope that the technology development that we do in terms of propulsion will have us physically building on a heavy-lift launch vehicle such that some time between 2020 and 2030, we will be on our way to destinations beyond low Earth orbit.

That is, you know, those are wishy-washy answers in terms of the, you know, leaving low Earth orbit, but that is—it is too early to tell you a definitive date for when we are going to do that.

Mr. DAVIS. You are saying with the Constellation Program we probably would not be able to be there for a much longer extended period?

Mr. BOLDEN. If I remember——

Mr. DAVIS. What are your plans now?

Mr. BOLDEN. —the program of record, you know, it did not have the International Space Station after 2015, because the cost of extending the International Space Station would push Constellation, Ares I, and Ares V even farther out. The program of record did not have landers, so we would not have—we would have a vehicle to go to the moon, but we would have no way to get humans to the surface. We would have, you know, we just—we would not get there in the time that you think we would under the existing program.

And that is not—please understand that is not an indictment on the people or the technology in the Constellation Program. The Augustine Committee points out very well. They found nothing technically wrong with Constellation any different from any other de-

velopment program in space, and they felt that NASA, given time and money, could take care of any challenges that they had. And the workforce is absolutely incredible. It is just that we found ourselves so far behind because of insufficient funding over the last 8 or ten years that ask the government to ask you as a Congress to approve a President's budget that would add $7 billion a year to try to catch up the Constellation Program, that was irresponsible in my estimation.

And so that is one of the reasons for my recommendation to the President that we take the course we are on now.

Mr. DAVIS. All of us are visionaries. We can predict the future, but we cannot see the future, and so as we engage in this debate further, I have a concern about canceling this program, and so, therefore, until we have more discussion I will be one advocate of continuing the program that we have. You must convince me that the vision I am not seeing that you have, that the program you are proposing is better than what we have with Constellation.

Mr. BOLDEN. Sir, I respect that, and that is exactly what I have to do. I promised the Chairman that, you know, we are not prepared at this time, and I apologized at the very outset of the hearing because we do not have the type of detailed program outline that one would normally expect when we were making a change like this, but we are working on it.

Mr. DAVIS. And that is what concerns me and I think many Members of this Committee.

Chairman GORDON. Ms. Dahlkemper is recognized.

Ms. DAHLKEMPER. Thank you very much, Mr. Chairman, and General Bolden, thank you for joining us today.

There has certainly been a lot of concerns echoes from one member after the other after the other, but I would like to go back to a little bit of what Representative Fudge was talking about in terms of education, STEM education, inspiring students, and maybe you can elaborate a little bit on a few points here.

You know, as we look at our youth, we have always used space exploration, Shuttle launches, to inspire our youth to encourage them to go into these fields. What is NASA telling, going to tell our youth about what you are doing, what is going on? How can you inspire them at this point?

Mr. BOLDEN. Congresswoman, we are actually—this summer we are going to try a program called Summer of Innovation, where we are going to connect youth with NASA centers, with NASA engineers around the country. We are going to let them do hands-on type of operations that may connect them with the International Space Station. In the 2011, budget we have money that is set aside to do interactive exploration where schoolchildren can actually participate with experiments and the like that are on board the International Space Station.

Dr. Sally Ride has a program now, and I forget the name of it. I think it is Space Cam, but it allows children today sitting in their classroom to take control of a camera that is on the International Space Station, and they point it wherever they want to point it, and they do projects. And those kinds of programs are going to continue, and we are confident that we can continue them now because the President has put an additional $20 million a year over

the next five years into my budget. We have put additional money in so that we can pull forward a number of the Earth science programs that were in the Earth science survey, so we are accelerating almost all of those tier one programs by a year and some by as many as two years. Those are things that are going—that we are going to use to inspire youth.

Ms. DAHLKEMPER. There is a pilot program this summer. Right?

Mr. BOLDEN. That is the—I am told not to call it a pilot, but it is a pilot program.

Ms. DAHLKEMPER. Okay.

Mr. BOLDEN. Yeah.

Ms. DAHLKEMPER. Are you—is there a sufficient lead time for NASA to be up and going for summer of 2010, on this program?

Mr. BOLDEN. Oh, yes, ma'am. We have been planning this since last fall, and we have had fits and starts I will admit, but we plan to have it operational in five states that will be selected competitively across the country.

Ms. DAHLKEMPER. How is that working?

Mr. BOLDEN. So far so good.

Ms. DAHLKEMPER. I mean——

Mr. BOLDEN. We have——

Ms. DAHLKEMPER. —how is that going to be determined, the five states?

Mr. BOLDEN. Oh. It is a competitive selection.

Ms. DAHLKEMPER. Uh-huh.

Mr. BOLDEN. We had a pre-solicitation conference a week ago, and we had 125 participants in the call, and we already have I think 27 notices of intent to apply to compete for the program, so that is pretty good.

Ms. DAHLKEMPER. And what happens this year, how will that be used to determine what you do with the 20 million for the fiscal year 2011?

Mr. BOLDEN. The $20 million that is in the budget is for increases in education programs that if I am able to do what I want to do, we want to modify, we want to radically change, if you will, the way that we do education in NASA where we are now going to be able to provide impact in coordination with the Secretary of Education, who taught me that you shouldn't do anything unless you can provide impact metrics, the data that says you have changed a child's life or you have really had an affect on them. And we are transforming the way we do business in NASA where we were advised that we are a program and project organization. We know how to do programs and projects, and we were advised that we should do education the same way.

And so the Summer of Innovation has a project lead or a project manager, and she is now developing a project plan with a budget, which is unlike programs that we have done in the past in NASA. We have definitive metrics that we will require people to meet, so we are looking to see whether or not we making middle school teachers more effective in their ability to reach students in the STEM subjects, and we will be looking at this over a three-year period of time.

Ms. DAHLKEMPER. And do you see any downsides to the fact that the cancellation of the Constellation Program and the Shuttle?

Mr. BOLDEN. You mean with——

Ms. DAHLKEMPER. In terms of inspiring.

Mr. BOLDEN. No, ma'am, I don't because, you know, Constellation would have had no—it would have not had any connection with the Summer of Innovation at all because the earliest that we would have seen Ares I fly, given the current plan that I asked about the other day, would have been 2015, 2016, so we will know whether the Summer of Innovation works or not. We would have known it two years prior to the earliest possible flight of any element of Constellation.

So Constellation had no impact or will have no impact on the Summer of Innovation or any of the other education programs we have on the books.

Ms. DAHLKEMPER. In terms of inspiring, you know——

Mr. BOLDEN. The Summer of Innovation is dependent on what we call NASA content.

Ms. DAHLKEMPER. Okay.

Mr. BOLDEN. That is the International Space Station, it is in existence today. It is not a dream.

Ms. DAHLKEMPER. Okay.

Mr. BOLDEN. And we are extending it an additional five years, so we have 10 more years to utilize that as an asset to support enhanced STEM education. We are going to try to put children aboard the International Space Station, what is the right word? Through the Internet.

Ms. DAHLKEMPER. Virtually?

Mr. BOLDEN. Virtually. That is—I apologize for losing my mind.

Ms. DAHLKEMPER. That is okay.

Mr. BOLDEN. But we are going to try to put them virtually aboard the International Space Station. We can do that for five more years than we were going to be able to do it before because the President has funded the extension of the International Space Station or is willing to fund it if the Congress concurs. So——

Ms. DAHLKEMPER. Well, I look forward to seeing the progress of this, and my time is up. So I yield back.

Mr. BOLDEN. Yes, ma'am.

Chairman GORDON. Mr. Wilson will be our final full Committee questioner, and then we move to our guests.

Mr. Wilson is recognized.

Mr. WILSON. Thank you, Mr. Chairman. Thank you for being here, Administrator Bolden.

NASA's economic impact to Ohio exceeds $1.2 billion and acts as a catalyst for over 1,200 aerospace-related companies in our state. This complies—these companies that employ more than 100,000 Ohioans are directly related to NASA Glenn. These are good-paying jobs that I would like to see protected regardless of the direction of human space exploration.

What specific roles do you foresee NASA Glenn playing in the NASA's future?

Mr. BOLDEN. Congressman, NASA Glenn has a bright future. If I look at things that are going on or are going to be going on with the 2011 budget, the increase in the aero budget, much of that will involve Glenn, primarily because they are a research center. As I told one of the—one of our fellow Members of the Committee ear-

lier, we are going to increase the amount of research that we do with rotor wing research. We are going to pick up the pace on icing research. So there are a number of things that Glenn will play a key role.

Mr. WILSON. Good. Thank you. Second question. NASA Glenn has a prominent role in the Constellation Program, including the components of Ares V and Lunar Lander. Therefore, are there very real fears that if the Constellation Program is canceled, that NASA Glenn could be negatively impacted?

Mr. BOLDEN. I don't, you know, I would encourage you to ask the former Glenn Center director, Woodrow Whitlow, but I think he would tell you that he has no fears that Glenn will falter from lack of the Constellation Program. Prior to my predecessor's desire to make sure that every center in NASA had a piece of the exploration pie so that everybody would have people working effectively, Glenn did not do the type of "exploration research" that they have been asked to do with Constellation Program. But they will still be doing exploration work, and most importantly, we will allow them to go back to being focused on aeronautics research as they have done before.

One of their greatest contributions today is the engine to cells on—the engine nozzles on the Boeing 747–800 that has been broadcast recently where—because they use the Chevron System on the engine nozzles, Boeing is realizing an increase in fuel efficiency, a decrease in noise pollution, and a decrease in air pollution. That is a product of Glenn research that was sitting on the shelf that somebody went back and found and Boeing picked it up.

So Glenn does ion engine research for, you know, in-space propulsion. They have a bright future.

Mr. WILSON. Good. One last question. The Space Power Facility at Plum Brook, it is a unique facility with the ability to simulate in-space conditions. However, in the fiscal year 2011 budget request it eliminates the Constellation effort, including the Orion Crew Vehicle, which was planned to be the first utilization of these new capabilities. The budget has no specific information about the future of Space Power Facility.

Can you give me some insight about this facility and how it would be used by NASA?

Mr. BOLDEN. Sir, that facility was sized for Orion and other vehicles in the Constellation Program, and when I look at commercial vehicles that are coming down the road or potentially coming down the road, they are all smaller than what we have. So the facility at Glenn we are hoping will—we will be able to attract DOD as well as commercial users to that facility. It—I don't see it being impacted that much by the cancellation of the Constellation Program.

Mr. WILSON. Thank you. Thank you, Mr. Administrator. I appreciate your answers.

Thank you, Mr. Chairman.

Chairman GORDON. Thank you, Mr. Wilson, and Mr. Bishop, you have been here the whole time. We appreciate you coming, and you are recognized for five minutes.

Mr. BISHOP. Thank you, Mr. Chairman. It has been most interesting. I appreciate you welcoming me back to this Committee, and

I realize I am here temporarily since my nameplate is put together with Scotch tape. Thank you very much.

General, everyone who has been here so far has thanked you for coming. I want to thank you, too, but to be very honest, very bold, if you and Ms. Garver had actually made better decisions, we wouldn't be here talking about this, and both of us would be much happier in that situation.

There are some specific questions I would like to ask. I will try and be as brief as I can with any of them.

It was brought out by Ms. Giffords, but you didn't really speak specifically to this particular issue, that with the Minute Man Ground Base Missile decisions that were made last year, as well as canceling of Constellation, has left the industrial base in shambles, and we obviously know that Secretary Gates was not consulted with this, Secretary Donnelly was not, ASCM—AFMC was not as well, and if obviously you talked about acquisitions, you obviously didn't listen to what they said.

So, sir, did you consult with the Department of Defense on this, on the impact to the industrial base before you made this catastrophic announcement?

Mr. BOLDEN. Congressman, let me be very careful about how I answer your question. I did not have detailed discussions with anyone——

Mr. BISHOP. Did anyone in your office then have discussions with them?

Mr. BOLDEN. Congressman——

Mr. BISHOP. I need you to be brief. I am sorry.

Mr. BOLDEN. —I have had informal conversations with senior persons in DOD from the time that I came into office because I wanted to reach out across agencies and the government. So I have talked with members of DOD. I have talked to them about, while not talking specifically about the impact of cancellation of the Constellation Program, I asked for information on the impact of—to the industrial base, particularly with reference to solid rockets.

Mr. BISHOP. Good. With whom did you speak?

Mr. BOLDEN. Sir, I—if you ask General Cartwright if I have spoken to him, he will tell you yes. I have spoken to him, but those were not formal meetings, and they were not formal deliberations.

Mr. BISHOP. Anyone else with whom you had consultations?

Mr. BOLDEN. Sir, those are—I can go through—I will provide you the information for the record.[4]

Mr. BISHOP. For the record. Good.

Mr. BOLDEN. I will get it to you.

Mr. BISHOP. Your comptroller wouldn't do that, so I would appreciate if you would do that right now.

The Department of—are you aware the Department of Defense's report to Congress on the Solid Rocket at Motor Industrial Base that was addressed last year?

Mr. BOLDEN. I am not aware of that report. I am aware of a report that Dr. Holdren prepared. I read it.

Mr. BISHOP. Not that one. Go back to the original one from acquisitions. I appreciate if you look especially on page 47 where it

[4] Page 90, line 2150, of the transcript (see Appendix 2: Additional Material for the Record).

says if there is delay and Constellation has a significant, negative impact on the defense side of this equation, canceling it has to be a very significant negative impact.

Mr. BOLDEN. I will go back and look at that.

Mr. BISHOP. Are you currently—because we talked to Secretary Donnelly yesterday. Are you currently having discussions with Secretary Donnelly on this issue?

Mr. BOLDEN. I am not—since you put it—me directly, I am not having discussions with anyone right now. There are discussions on the Space Policy Review that is underway and persons in my organization are participating in those meetings.

Mr. BISHOP. Since he said he would have to get back to me on something of record, would you be willing to talk to him about that?

Mr. BOLDEN. Yes, sir.

Mr. BISHOP. I would appreciate that.

Ms. Edwards asked you specifically about the Russians and the costs that would come to this particular program. When the contract currently with the Russians is up and they have the monopoly on spaceflight which will take place for quite some time, do you have any anticipation or could you give me any kind of guess of what they will charge us to provide that services for us? Is there any—do you have any clue of what that will be?

Mr. BOLDEN. Sir, we are in negotiations with the Russians right now, and so I would prefer not to—in fact, I won't discuss costs or any progress on that.

Mr. BISHOP. Do you have an estimate then on cancellation costs? Your budget puts it at around $2.5 billion.

Mr. BOLDEN. We are evaluating right now what the potential costs, cancellation costs are, and——

Mr. BISHOP. Thank you.

Mr. BOLDEN. —we can get that to you for the record, sir.[5]

Mr. BISHOP. Thank you. I appreciate that. That is consistent with, I think it was Mr. McCaul that you said that to. You really don't have a handle on what that cancellation cost would be, which I hate to admit this, to me is somewhat of a backwards approach. It would be nice for a Congressman or somebody who is making a policy decision, if we knew what the costs would be before you actually make that decision and jump to the next particular level.

I have only got about 40 seconds with you, and I apologize for that. There are some other questions. There is a Space News article that came out which seemed to contradict the letter that you sent to us. I hope for the record some time you will clarify whether the Space News was wrong in its implications, or whether you are actually closing down programs of record or whether your letter was wrong to us.

But I have to say just one last thing. When you said you are building a bold, new path for the future and you are coming up with was it, programs, Summers of Inspiration for kids to encourage them, in all due respect, when you have a President and you who said you want to encourage kids to become involved in science, math, and engineering or STEM programs, I have to really admit

[5] Page 92, line 2198, of the transcript (see Appendix 2: Additional Material for the Record).

to you that the Summers of Inspiration is not going to fool a kid in college or in high school or junior high right now who looks at 20 to 30,000 private sector jobs who are involved in science, math, and engineering, being given a pink slip and the kind of chaos that goes to their particular life is not going to encourage anyone else to become involved in this area or any other area.

This is a negative impact. It is a negative message. There is certainly no inspiration with this. This is not a program for a bold, new path. It is more like managing America's decline, and I am very much disappointed in the approach that NASA is taking on this particular effort, and I apologize right now. I wish I could give you more time.

I only got—I have already gone over 33 seconds and counting, and I apologize for that, Mr. Chairman, as well. I tried to get it in five minutes.

Chairman GORDON. Okay.

Mr. BISHOP. But I am sorry that we have to meet here.

Chairman GORDON. Dr. Griffith, welcome back, and you are recognized for five minutes.

Mr. GRIFFITH. General, I appreciate seeing you again, and I know the bipartisanship in this room is heartwarming to you. That is a joke. If you got it.

Mr. BOLDEN. I laughed. No one else did.

Mr. GRIFFITH. Teasing. I do think, though, that you being here, and I must say that—and I certainly disagree that this—if we were in the business community, this has all the earmarks of a hostile takeover, and unfortunately, your kind face and your experience and the deep, deep respect that we have for you and what you have done for America makes it very difficult for us not to come to you with a smile and a good heart.

We are deeply concerned, though, that whether it be Space X, a company that is reasonably new on the scene, or whether it be a Boeing or Northrop Grumman or whoever, we realize that difficulty when you pit two private or three private companies in a bidding war for an endeavor that has all to do, so much to do with our national defense.

We are witnessing a delay right now in our refueling tankers with Boeing and other companies, and suppose we run into that same difficulty, and we recognize that China is on its way to the high ground, and we find ourselves in a bidding war or a bidding conflict, or we find ourselves in the legal system that is now slowing down whether these companies can, in fact, fulfill their mission or even resolve the bidding process in years past.

We believe, and I think many of the Committee members believe, that this is a national security issue, and a national security issue that you privatize without control puts us in danger as a country, because it is the high ground.

We are concerned that should a CEO change at Boeing or a CEO change at Space X or a *Columbia* accident occurs in one of these private companies, they will not be able to survive it. Only the U.S.A. can survive that with the will of the American people. We believe deeply in NASA. It is our heart, and it our soul. If we begin to divide our heart and soul with labels that say Space X or Boeing,

and we have a failure, where will the American people be as far as their willingness to support manned spaceflight.

We are greatly concerned about this. The thing that is of great concern to us is one of the things that makes me believe that this is an unfriendly takeover is something that you said that we will be happy to involve you in the deliberations as we move forward. But actually the decision to cancel Constellation was done without those deliberations. So we are all very, very suspicious.

And so you can—I am a great—it is of great concern to me, of course, because I represent Marshall Spaceflight, but it not about jobs. The heart and soul of America is NASA. If we do anything, anything to detract from that we are going to lose, and we really can't afford to lose. We are five percent of the world's population, 95 percent of the would lives somewhere else. We are number one in manned spaceflight, and if we interrupt this culture of manned spaceflight, if we interrupt these people who are handing down their wisdom from generations of generations of manned spaceflight engineers, we are making a huge mistake.

And to privatize this with a Space X or a Boeing or a Northrop, getting involved in the legal ramifications of a request for a proposal that may take two years or a bidding process that may be interrupted by the judicial system. We really need to think about this some more. We need to really, really go over it because America is a difficult place to do business.

And I appreciate you. I truly do, but I disagree completely with the decision, and it is not about budget. If the conversation could take place between you and the President and you said, Mr. President, we need $3 billion a year for the next five years to make sure Constellation is on target and on time, and there is $800 billion over here in this stimulus, could you move 3 billion a year over into our space program so that we can be number one, and we won't have to watch the Chinese land on the moon from our living rooms? Mr. President, couldn't we do that? Wouldn't that be a good idea? And I will bet you with your persuasiveness the answer would be yes, good idea, General.

Anyway, thank you very much for being here. I appreciate it.

Mr. BOLDEN. Thank you very much, Congressman.

Chairman GORDON. And Mr. Posey, you are going to close us out today.

Mr. POSEY. Thank you very much, Mr. Chairman.

Following up on Congressman Parker's comments, I know it seems like a big reach but it would take about one percent of the stimulus fund to fly the Shuttle for another 5 years.

I had another meeting earlier so I missed your testimony apparently when you refused to disclose who made the decision to cancel Constellation. I don't want to beat that horse anymore other than to say I am deeply disappointed in the alleged, most transparent Administration in the history of this country not to be able to get a direct answer on that, and a lot of people are, I think everyone shares that same question.

When the President was campaigning in my county, he promised that he would close the gap between Shuttle and Constellation, and number two, he would keep America first in space. He didn't close the gap. He made the gap eternal, and low Earth orbit sure as

not—hell is not keeping us first in space. You know it, I know it, he knows you and I both know it, but it doesn't seem to change anything. The rest of the world knows it, too.

We have a focus on commercial in the future, and I love commercial spaceflight. I have spent about 20 years trying to help make commercial more profitable. I think there is a huge opportunity for there. If we would have done that earlier, there wouldn't even be a French Ariane today, but the reality is there is no profit in commercial rockets for human exploration unless we pay them, and we should be taking the lead in doing that anyway.

I read your statement today, and it has a plethora of subjects that you said you were going to focus on, and we have heard more about also focusing on education, and I am just sad to see that the focus of NASA is not what this Nation has always presumed it to be, and that is first and foremost human space exploration.

I am chagrined to hear the allegations that the Constellation Program is over budget when you know, I know, and they know we both know it is under-funded. Russians have already increased the cost of ferrying the astronauts of ours and the other nations we are pledged to ferry back and forth from 30 million to 51 million per, and I just wonder if you would dare to guess what that may be ultimately when we no longer have an alterative like the Shuttle to do that.

We have not received a NASA workforce transition report since last summer despite the 2008 legislation that requires it. Apparently somehow it got sidetracked by Augustine. Given the importance allegedly placed on workforce, you know, you have to wonder why we are looking at laying off thousands of high-skilled workers, and the question is when we could expect to get our next report.

Is safety really a legitimate objection to continue with the Shuttle? The questions that beg for an answer is why we aren't going to continue launching the ones we have, and aren't they, in fact, designed, engineered, and built for 100 missions, and I think Endeavor has less 30 right now.

Augustine report also referred that as—to that as one of the most reliable, as the most reliable, I think talked about over 98 percent reliability.

You know, thousands and thousands of space workers are going to be put in the unemployment lines across this country, and I know a lot of the people in my district are wondering exactly how many reductions NASA is going to make at headquarters. They are expecting a commensurate amount of reductions as we lay off thousands of people around the country, and I wonder if you would comment on that.

And if there is not time to address all these, and it is obvious there won't be, I wonder if you would be kind enough to respond to me in writing to these questions at your earliest convenience.

Unfortunately, history will show that unlike the landing of Apollo when there was a giant step for mankind, we are going backwards now. This is a giant step from greatness to meritocracy. Anything but extraordinary I think in the future, and I think it just a sad day for America.

And the final question I have is what would it take to get you to consider further renewing your interest in Constellation?

Mr. BOLDEN. Congressman, I will get you answers for the record for the questions you asked about manpower, particularly that at headquarters.[6]

In terms of interest in Constellation, there are aspects of the Constellation Program that I want to capture, and I want to keep, and some of the studies that I have asked to be done right now are helping us to determine what technologies, what projects that we have in the Constellation Program that we cannot do without, and it will serve as a nucleus for emerging programs.

If I give you an example, two examples, from the Constellation Programs of things that we have already found to be needed and will—and are going to be applied. The thermal protection system studies that were done for Constellation determined that there is a thermal protection system that the folk from Space X could use, and they have chosen to use that on their vehicle.

So we have gained an incredible amount of knowledge, a wealth of knowledge from the Constellation Program that I think will be—will carry on to the programs that we develop in the wake of the cancellation of Constellation if that is the final decision.

When we look at escape systems, something that the Shuttle does not have, at the Langley Research Center we did a test on something called MLAS, Max Launch Abort System, which was highly successful. That is a system that we have recommended that the folk at Space X take a look at because they want to use a pusher-type system also, and so rather than have them go out and reinvent the wheel, we have suggested that they look at that product of the Constellation Program.

So there are a number of aspects of the Constellation Program that I would hope we would be able to capture and to use in future programs.

Chairman GORDON. Thank you. Yesterday we had Dr. Holdren here, and before the meeting started, the hearing started, Mr. Hall asked me does he bruise easily, and I will report back to him that you do not bruise easily, and we thank you, Administrator Bolden, for being here.

The record will remain open for two weeks for additional statements from members and for answers to any of the follow-up questions the committee may ask the witness, and the witness is excused. The hearing is adjourned.

Mr. BOLDEN. Congressman, thank you very much.

[Whereupon, at 12:16 p.m., the Committee was adjourned.]

[6] Page 100, line 2402, of the transcript (see Appendix 2: Additional Material for the Record).

Appendix 1:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration

Questions submitted by Chairman Bart Gordon

Q1. Many attempts have been made to leverage and/or establish commercial space markets with limited or no success (i.e. commercial Atlas/Delta, Space Imaging, Astrolink, TDRSS, Landsat, Comet, RocketPlane Kistler, Rotary Rocket, Beal, X–33/VentureStar, and many more). Considering the current economic environment and the limited availability of private capital, what specific indicators do you have that you confidence that a successful business case will exist for commercial crew services over the next three to five years?

A1. NASA has not done an analysis about the business case for future commercial crew providers. Such an analysis would be part of a review of any proposals submitted for future work. However, there are general indicators that such a market exists. For example:

- From an historical perspective, Russia and the U.S. have been providing human space transportation services to astronauts from other countries since 1978. Since that time, Russia and the U.S. have transported nearly 100 astronauts representing 30 nations. In addition, eight people have flown to space in the past decade as spaceflight participants.
- Another strong indicator came from NASA's CCDEV solicitation. In Answer to NASA's CCDEV solicitation for commercial crew spaceflight concepts, the Agency received 36 proposals—an indicator that there is robust interest from U.S. industry in developing human spaceflight capabilities.
- Helping to support an enhanced U.S. commercial space industry will create new high-tech jobs, leverage private sector capabilities, spawn other businesses and commercial opportunities, and spur growth in our Nation's economy.
- Most importantly, the Administration's proposal to extend and fully utilize the International Space Station provides a reliable, sustainable market for commercial human space transportation services likely too 2020 or beyond.

Studies in the public domain suggesting that commercial providers can be successful include:

- Collins, P. and Isozaki, K. "Recent Progress in Japanese Space Tourism Research" IAC Italy, October 1997.
- O'Neil, Bekey, Mankins, Rogers, Stallmer "General Public Space Travel and Tourism" NASA–MSFC, March 1998.
- Aerospace Commission "Final Report of the Commission on the Future of the United States Aerospace Industry," November 2002.
- Space Tourism Market Study, Futron Corporation, 2002.
- Webber, D. and Reifert, J. "Filling in Some Gaps", Executive Summary of the Adventurers' Survey of Public Space Travel, September 2006.
- Commercial Spaceflight Federation "Commercial Spaceflight in Low Earth Orbit is the Key to Affordable and Sustainable Exploration Beyond", Input to the Review of U.S. Human Space Flight Plans Committee, June 29, 2009.
- Final Report of the Review of U.S. Human Spaceflight Plans Committee, 2009.

Q2. In December of 2009, the Committee held a hearing on the U.S. aerospace workforce and industrial base in which retired Lockheed Martin executive, Mr. Tom Young, testified that "Without a challenging and meaningful space program, this national capability [spaceflight workforce] will atrophy. It can only be maintained by inspiring use. It has a limited shelf life." In the absence of a continuing government flight program to sustain this "national treasure" of a spaceflight workforce that Mr. Young describes, how do you plan to ensure that NASA's corporate knowledge and skill in conducting human spaceflight operations will not have exceeded its "shelf life" when the government does make a decision on a specific program to send humans beyond low-Earth orbit?

A2. NASA agrees that to maintain our leadership in space, we need challenges that inspire the Nation. The question before NASA is how to provide these challenges in the post-Shuttle era.

At the highest level, the President and his staff, as well as the NASA senior leadership team, closely reviewed the Augustine Committee report, and we came to the same conclusion as the Committee: The human spaceflight program and the Constellation Program were on an unsustainable trajectory. To continue on the previous path we had to decide to either continue the International Space Station (ISS), support a program to get humans beyond low-Earth orbit (LEO), or to make even deeper cuts to the other parts of NASA's budget. Further, we would have insufficient funding to advance the state-of-the-art in any of the technology areas that we need to enable us to do new things in space, such as lowering the cost of access to space and developing closed-loop life support, advanced propulsion technology, and radiation protection.

The President recognized that what was truly needed for beyond LEO exploration was game-changing technologies; making the fundamental investments that will provide the foundation for the next half-century of American leadership in space exploration. Therefore, the FY 2011 budget request would ensure continuous American presence in space on the ISS throughout this entire decade, re-establish a robust and competitive American launch industry, launch more robotic probes into our solar systems as precursors for human activity, invest in a new heavy lift research and development program, and build a real technological foundation for sustainable, beyond-LEO exploration, with more capable expeditions in lunar space, and unprecedented human missions to near-Earth asteroids, Lagrange points, and, ultimately, Mars.

The redirection to a flexible path strategy provides inspirational challenges, maintains the budget top-line and leverages government investment through partnership with the commercial sector. Maintaining and increasing national knowledge and skill in conducting human spaceflight operations is a cornerstone of the President's proposed space exploration strategy.

Under the new Commercial Crew Transportation program, existing aerospace industry knowledge (including NASA's expertise) will now be shared with the commercial sector, as well as other NASA programs. To some degree, this is already occurring within the Commercial Orbital Transportation Services (COTS) program as NASA engineers sit side-by-side with our partners and evaluate their performance. New insights and innovations are sure to emerge as NASA experts interact with industry partners.

The International Space Station (ISS) is fully outfitted and operational to support six-person Expedition crews and the conduct of research and technology development. The FY 2011 President's Budget provides additional funding to extend the lifetime of the ISS beyond 2015 and to increase ISS functionality and utilization. The goal is to fully utilize ISS' capabilities to conduct scientific research, improve our capabilities for operating in space and demonstrate new technologies developed through ISS or other NASA programs. These efforts will help to ensure the retention of human spaceflight operations skills and experience.

Lastly, NASA has many science missions in the operations phase that can provide valuable training grounds for mission and flight operations. The FY 2011 budget proposal, for example, includes two new programs—a Flagship Demonstration Program and an Enabling Technology Development Program—that would invent and demonstrate large-scale technologies and capabilities that are critical to future space exploration, including cryo-fluid management and transfer; automated rendezvous and docking, closed-loop life support systems; in-situ utilization and advanced in-space propulsion. Once developed, these technologies will address critical requirements needed to send crews to a variety of exciting destinations beyond LEO. The flagship projects will be funded at $400 million to $1 billion over a period of up to five years, including launch costs, while shorter-duration enabling projects will be funded at $120 million or less and will focus on near-term development and demonstration of prototype systems to feed flagship and robotic precursor missions. Such projects could include laboratory experiments, Earth-based field tests and in-space technology demonstrations. By allowing for flight demonstrations, some at a flagship scale, this Technology Development and Demonstration effort resolves the achievement gap between lab demonstration and flight testing that might otherwise prevent NASA from implementing the capabilities that are critical for sustainable human exploration beyond Earth in a timely manner.

It should be noted that the same need for inspirational challenges and limited shelf life affects the nation's technology research and development workforce. Many independent reviews have found these efforts to be woefully under-supported, especially in the last five years as the national space industry's efforts have been tightly focused on the development of a particular set of hardware for human spaceflight. The FY 2011 budget proposal for NASA rebalances the nations support and utiliza-

tion of the human spaceflight operations workforce and the space technology research workforce.

Q3. The Administration's budget request for FY 2011 proposes significant changes to NASA's human spaceflight program that would end the U.S. government's capability to access low-Earth orbit after the retirement of the Space Shuttle. In the absence of any government system to serve as a backup, does the proposal signal an Administration decision to pay whatever is required to keep the would-be commercial providers financially viable for as long as the government needs to get its astronauts into space? If not, what recourse will you have once the government's development program is cancelled?

A3. The FY 2011 budget request builds upon NASA's commercial cargo efforts by providing significant funding for the development of commercial human spaceflight vehicles, freeing NASA to focus on the forward-leaning work we need to accomplish for beyond-low-Earth orbit missions.

NASA is preparing a strategy to support the development of commercial crew transportation services so that the Agency is prepared to proceed if Congress provides funding in FY 2011. Therefore, it is too early to say, specifically, what NASA's procurement strategy will be or how much the Agency will pay for these services, once developed.

In general, however, NASA's plan is to award FY 2011 development funding for multiple proposals, thus increasing the likelihood for developing a commercial crew vehicle from multiple partners. Then after the commercial crew services procurement is released, NASA expects that more than one partner will be selected to supply those services, thus providing redundancy of capabilities and competition. NASA has a transportation demand of six ISS crewmembers per year. Additionally, NASA has currently purchased seats on the Russian Soyuz through 2014 and has legislative authority to purchase seats through mid-2016, should we need to procure additional services.

With regard to commercial cargo services, NASA agrees that timely commercial cargo capability is critical for effective ISS operations. Without commercial cargo capability, the crew size and research operations planned for ISS would need to be reduced. Therefore, NASA will pre-position spares on board the ISS with the final logistics flights to provide some margin for delay in commercial cargo services. Additionally, NASA plans to rely on the transportation capabilities of Russia, the European Space Agency (ESA) and Japan to transport cargo to ISS. Russia's Progress vehicle has been providing cargo services to ISS through a contract with NASA. The ESA Automated Transfer Vehicle had a successful initial flight to the Space Station in 2008. The Japanese HII Transfer Vehicle had a successful first flight in 2009. ESA's and Japan's services are provided through barter agreements. It should be noted that NASA does not plan to continue to procure Progress cargo resupply services after 2011, opting instead to rely on U.S. commercial cargo delivery capabilities provided through NASA CRS contracts.

Q4. In your testimony, you stated that "Under this program the United States will pursue a more sustainable and affordable approach to human space exploration through the development of transformative technologies and systems." What is the basis for claiming that the proposed approach will be more "sustainable and affordable" when plans, a specific architecture for human exploration, and new technologies required to enable them have not been developed or demonstrated?

A4. The FY 2011 budget request is good for NASA because should the necessary funding be provided by Congress, it will set Agency on a sustainable path that is tightly linked to our Nation's interests. One measure of this is that it increases the Agency's top-line, in a time when many agency budgets have been flat or taken a cut. Even more, it reconnects NASA to the nation's priorities—creating new high-tech jobs, driving technological innovation, and advancing space and climate science research. It puts the Agency back on track to being the big-picture innovator that carries the Nation forward on a tide of technological development that creates our future growth. We should make no mistake that these are the drivers for NASA's proposed budget increase of $6 billion dollars over the next five years.

At the highest level, the President and his staff, as well as NASA senior leadership, closely reviewed the Augustine Committee report, and came to the same conclusion as the Committee: The Constellation program was on an unsustainable trajectory. They determined that, given the current budget environment, Constellation's funding needs would have required terminating support of the International Space Station (ISS) in 2016 and we would not have had sufficient resources to significantly advance the state-of-the-art in the technology areas that would be needed to enable lowering the cost of heavy-lift access to space, and developing closed-loop

life support; advanced propulsion technology; and radiation protection and other technologies on a faster schedule. The President determined that what was truly needed for beyond LEO exploration was game-changing technologies; making the fundamental investments that will provide the foundation for the next half-century of American leadership in space exploration. At the same time, under the new plan, NASA would ensure continuous American presence in space on the ISS throughout this entire decade, re-establish a robust and competitive American launch industry, start a major heavy lift technology program years earlier, and build a technological foundation for sustainable exploration beyond-low Earth orbit.

The President's FY 2011 budget request outlines an innovative course for human space exploration, but does not change our goal—extending human presence throughout our solar system. NASA's exploration efforts will focus not just on our Moon, but also on near-Earth asteroids, Lagrange points, and ultimately Mars. The President has voiced his commitment to sending humans to orbit Mars by the mid-2030s with a landing on Mars to follow. While we cannot provide a date certain for the first human visit, with Mars as a key long-term destination we can identify missing capabilities needed for such a mission and use this to help define many of the goals for our emerging technology development. The research and technology investments included in this budget describe the many near-term steps NASA will be taking to cultivate the new knowledge and breakthrough capabilities required for humans to venture beyond low-Earth orbit (LEO) to stay.

NASA's will lead the Nation on this new course of discovery and innovation, providing the technologies, capabilities and infrastructure required for sustainable, affordable human presence in space. Many of these capabilities have been recommended consistently for at least 24 years in national level reports of committees and commissions addressing future human space exploration. NASA's investment in gaining critical knowledge about future destinations for human exploration, as well as transformational technology development and demonstration will serve as the foundation of NASA's ongoing space exploration effort, broadening opportunities for crewed missions to explore destinations in our solar system that we have not been to before. We have not sent people beyond low-Earth orbit in 38 years, and this budget gives us the great opportunity to focus on scouting and learning more about destinations to further explore our solar system and to develop the game-changing technologies that will take us there. It is important that we pursue these objectives to continue leading the world in human space exploration.

Pursuant to the President's proposed new course, NASA has initiated planning activities to be able to effectively and efficiently implement these new activities in a timely manner upon Congressional enactment of the FY 2011 budget. In April, NASA outlined for the Committee the Agency's planned major program assignments across the Agency's Centers for new or extended activities proposed as part of the President's FY 2011 budget request. These planned assignments build on the deep knowledge and expertise that NASA has built up over five decades, recognize the wealth of experience, commitment, and expertise resident at the NASA Centers, and expand upon the strengths at each Center. Additionally, following the release of the FY 2011 budget request, NASA established study teams to ensure we understand the steps (and the implications of those steps) that would need to be taken for an orderly transition of the Constellation Program and to plan for the implementation of the new initiatives in the Exploration program. The work undertaken by these teams is a necessary part of that planning.

NASA is taking prudent steps to *plan* for the new initiatives included in the FY 2011 budget request, including Requests for Information (RFI), workshops, and preliminary studies. NASA is eager to seek external input from industry, academia, and other partners, and plans to accomplish this via a series of RFIs and industry workshops conducted this spring and into the summer. Doing so will ensure that NASA receives important feedback from our space partners before it begins to finalize its implementation plans for the proposed technology demonstrations and human spaceflight systems development activities that will be supported by the FY 2011 budget, once approved by Congress. During CY 2010, NASA plans to issue a series of program formulation documents seeking input from the broader space community.

Finally, NASA also has established the Human Exploration Framework Team (HEFT) to serve as a cross-Agency planning activity. The team is being led by the Exploration Systems Mission Directorate (ESMD) and staffed with technical leaders from across NASA Centers. The team is focused on developing and reviewing the integrated set of requirements and technologies required for future human spaceflight missions to many destinations, including Mars. As part of its broad integration charter, HEFT will develop implementation recommendations on the performance and pacing requirements for the technologies needed for future human ex-

ploration missions using "design reference missions," or DRMs. These DRMs will be the basis for validating capabilities and missions for five, 10-, and 15-year horizons, with milestones including crewed missions beyond the Moon into deep space by 2025, sending astronauts to an asteroid, and eventually landing on Mars. NASA expects to have initial products from the HEFT team this summer.

Q5. In its report, the Columbia Accident Investigation Safety Board commented on the human spaceflight culture at NASA:

> *"As the Board investigated the Columbia accident, it expected to find a vigorous safety organization, process, and culture at NASA, bearing little resemblance to what the Rogers Commission identified as the ineffective "silent safety" system in which budget cuts resulted in a lack of resources, personnel, independence, and authority. NASA's initial briefings to the Board on its safety programs espoused a risk-averse philosophy that empowered any employee to stop an operation at the mere glimmer of a problem. Unfortunately, NASA's views of its safety culture in those briefings did not reflect reality. Shuttle Program safety personnel failed to adequately assess anomalies and frequently accepted critical risks without qualitative or quantitative support, even when the tools to provide more comprehensive assessments were available.*
>
> *Similarly, the Board expected to find NASA's Safety and Mission Assurance organization deeply engaged at every level of Shuttle management: the Flight Readiness Review, the Mission Management Team, the Debris Assessment Team, the Mission Evaluation Room, and so forth. This was not the case. In briefing after briefing, interview after interview, NASA remained in denial: in the agency's eyes, "there were no safety-of-flight issues," and no safety compromises in the long history of debris strikes on the Thermal Protection System. The silence of Program-level safety processes undermined oversight; when they did not speak up, safety personnel could not fulfill their stated mission to provide "checks and balances." A pattern of acceptance prevailed throughout the organization that tolerated foam problems without sufficient engineering justification for doing so." CAIB, Volume 1, pages 177–178*
>
> *NASA has worked to change its culture and to ensure that decisions regarding Shuttle launches involve openness, opportunities for all levels of Shuttle employees to identify technical concerns and risks and to challenge decisions, and to have a forum in which NASA's human spaceflight personnel can be heard. An independent technical authority is now in place. In addition, NASA has in place a process for safety and mission assurance, a NASA Engineering and Safety Center, NASA Safety Center, and an Independent Verification and Validation Facility. How can Congress ensure that an equivalent or greater degree of institutional support is in place to foster a culture of safety and openness of technical debate and to provide technical analysis that may be needed to help reach decisions about the readiness to launch American astronauts into space on commercial crew transportation vehicles?*

A5. Since issuance of the Columbia Accident Investigation Board report, NASA has embedded the elements of technical authority and an open culture within all of its processes. Senior leadership routinely espouses these ideals, and they are documented within the highest level of NASA policy and establish the basis from which technical authority (including not only the safety and mission assurance discipline, but also the engineering and health and medical disciplines) and the openness of technical debate are codified and encouraged, respectively, for all Agency activities. The key elements of NASA technical authority and openness to debate include checks and balances between the programmatic chain of command and the technical authorities related to risk-related decisions (and in the case of human activity checks and balances, include the involvement of the risk takers in the risk decision making). Opportunities for dissent and appropriate mechanisms to exercise and facilitate such dissent are also documented in NASA policy and apply to all activities in which the Agency participates or that the Agency performs. These concepts and requirements are documented in various levels of Agency documentation, but are highlighted in keystone policy documents of the Agency (NASA Policy Directive [NPD] 1000.0, the Governance and Strategic Management Handbook; NPD 8700.1, NASA Policy for Safety and Mission Success; and, NPD 7120.4, NASA Engineering and Program/Project Management Policy).

The NASA management commitment to the concepts of technical authority and openness of technical debate, along with the documented policies and requirements related to these concepts, establishes the framework that permits effective implementation of the concepts. The framework is important, but the key to implementation is having the technical wherewithal and knowledge base to exercise authority

and provide an independent voice in the technical debates. Elements of the safety and mission assurance, health and medical, and engineering communities funded via the Center Management and Operations budget establish the core of the independent technical authority within the Agency. Additionally, NASA recognized the need to establish independent sources of specialized, technically competent and qualified personnel to augment the technical authority, so the NASA Safety and Engineering Center, the NASA Safety Center, and the NASA Independent Verification and Validation facility were established and funded via the Agency Management and Operations budget.

This infrastructure and culture will continue to apply to NASA endeavors, including commercial crew transportation vehicles for NASA astronauts. The Aerospace Safety Advisory Panel (ASAP) will continue to monitor application of our technical authority and checks and balances. The ASAP has been continuously evaluating NASA's implementation of the recommendations of the Columbia Accident Investigation Board, focusing on the checks and balances the Agency has instituted to arrive at informed decisions. The ASAP reports provide an independent assessment and should provide early indications if the NASA safety culture and technical authority begin to erode. Additionally, NASA collects safety-related information though a variety of means, including internal surveys, external surveys, and when a mishap investigation board takes witness statements. Protecting this type of information from public disclosure will encourage open and honest communication about risks and potential mishaps. Further, it will assist in ensuring safety of the public and a safer workplace for employees, allowing managers to make more informed decisions about the risks associated with NASA's activities. NASA previously sought legislative authority to protect this safety-related information from public disclosure, and we recommend that Congress consider this as an element that will help maintain the open reporting of safety issues.

Q6. What will the $5M requested for participatory exploration be used for and what are the objectives to be achieved? Which institution (NASA or external) will manage the program and what is the budget for the Participatory Exploration Office mentioned in the budget justification?

A6. Participatory Exploration is the active involvement of individuals in the experience of, as contributors to, and collaborators in, NASA's research, science and discovery activities. The program will increase the following:

- opportunities for personal connections with NASA and its missions;
- public interest in STEM; and,
- NASA's access to the interest, knowledge, skills, creativity and innovation that exists outside the NASA community.

However, to enable this, NASA must make its research, development and related discoveries more open and transparent. Additionally, participatory exploration must embody far more than simply exposing people to or educating them about NASA's discoveries and exploration activities. Participatory exploration must encourage individuals to contribute their creativity and capabilities to NASA's mission of discovery.

President Obama has recognized the incredible benefits of participatory exploration for NASA and the Nation and has provided $5 million in annual funding for NASA participatory exploration efforts as part of the FY 2011 budget request. Currently, Participatory Exploration is housed within NASA's ESMD. In general, it is envisioned that the Participatory Exploration Office would support research on new technologies that can increase public participation, coordinate NASA-wide efforts to incorporate new participatory exploration approaches into future work, and act as a clearinghouse for identifying and communicating best practices both internally to NASA and externally to our communities. While maximizing the strong efforts NASA already places on reaching various audiences, Participatory Exploration will foster, facilitate and support active public engagement and collaboration by combining improved technology and Open Government practices to provide a broad spectrum of engagement possibilities for the maximum benefit of the public. The activities the Participatory Exploration Office supports and coordinates would help empower citizens to become not just consumers of NASA innovation but co-creators of knowledge and ideas to advance space exploration.

Questions submitted by Representative Ralph M. Hall

Q1. The Augustine Committee noted that developing a new, safe, human-rated spaceflight system would require a phased funding increase of $3 billion per

year above current levels. This Administration budget request does the contrary; it removes $5.8 billion (compared to the FY 10 budget) from the program, yet asserts that commercial companies can get astronauts to low Earth orbit as safely as Constellation on a similar or better schedule.

a. What evidence or analyses convinced the Administration that commercial providers can meet these performance goals? Please provide the Committee with a copy of any analyses.

A1. NASA is in the process of developing a commercial crew development plan that would include requirements and performance goals for commercial crew providers. Upon receiving proposals, NASA will carefully evaluate those responses on an individual basis to determine if they meet the Agency's needs for the commercial crew program.

With regard to any specific analysis, per Section 306 of OMB Circular A–11, "Communications with Congress and the Public and Clearance Requirements, budget formulation documents and discussions are of a pre-decisional nature and thus cannot be provided for the public record. However, in general, the Administration relied heavily on the Augustine Report which stated that: "Commercial services to deliver crew to low-Earth orbit are within reach. While this presents some risk, it could provide an earlier capability at lower initial and life-cycle costs than government could achieve. A new competition with adequate incentives to perform this service should be open to all U.S. aerospace companies. This would allow NASA to focus on more challenging roles, including human exploration beyond low-Earth orbit based on the continued development of the current or modified Orion spacecraft." The Committee also found, "Moving towards commercial crew services will also contribute to the evaluation on Economic Expansion. Together with commercial launch services for cargo to the ISS, and potentially in-space refueling, the commercial crew options could further stimulate the development of a domestic competitive launch capability. Eventually, it could stimulate a commercial service for human transport to low-Earth orbit that would be available to other markets."

It is important to remember that at the highest level, the President and his staff, as well as the NASA senior leadership team, closely reviewed the Augustine Committee report, and we came to the same conclusion as the Committee: the human spaceflight program and the Constellation Program were on an unsustainable trajectory. Therefore, the President recognized that what was truly needed for beyond LEO exploration was game-changing technologies; making the fundamental investments that will provide the foundation for the next half-century of American leadership in space exploration.

NASA understands that human space exploration has driven technological advances that have made the United States more competitive in the global economy. NASA's new path forward will not surrender the United States' leadership in space but rather will enable the Nation to pursue exploration in new ways. The FY 2011 budget request invests in commercial providers to transport astronauts to the ISS. By allowing commercial providers to provide more routine access to low-Earth orbit, NASA will once again be able to focus on the most difficult technological puzzles to solve such as building rockets that allow humans to reach other planets in days rather than months and protecting humans from radiation during interplanetary travel. NASA's FY 2011 budget request includes investments in a new space technology research and development, and a new heavy-lift and propulsion technology development program.

More specifically, the FY 2011 budget request challenges NASA to develop the necessary capabilities to send Americans to places that humans have not explored before, including longer stays at exciting new locations on the Moon, near-Earth objects, strategic deep space zones called Lagrange points, and the planet Mars and its Moons. We have not sent people beyond LEO in 38 years, and this budget gives us the great opportunity to focus on scouting and learning more about destinations to further explore our solar system and to develop the game-changing technologies that will take us there. It is important that we pursue these objectives to continue leading the world in human space exploration.

Q2. NASA's budget request for commercial crew and cargo procurements states that, "Government requirements are kept to a minimum and are only concerned with assuring safe interaction with the ISS. The partners are not required to follow the standard NASA Program and Project Management Processes and Requirements, NPR 7120.5." In other places the budget says crew safety won't be compromised and your own testimony acknowledges the imperative of safety, yet NASA's ability to verify safety standards relies on NPR 7120.5.

a. How are we to interpret NASA's process for ensuring safety? Will commercials be held to a lesser standard?

A2a. NASA is in the process of developing a plan that supports the development of commercial crew transportation providers to whom NASA could competitively award crew transportation services. NASA released the preliminary plan using a NASA Request For Information on May 21, 2010. Responses were due on June 18, 2010 and NASA is in the process of reviewing and evaluating the responses. NASA plans to finalize the Commercial Human-Rating implementation plan in time to support an open-competition when NASA pursues the development phase of commercial crew transportation systems.

Safety is and always will be NASA's first core value, so the Agency will provide significant oversight over any commercial venture. U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so. Therefore, we will establish strict oversight processes to ensure that our safety standards are met. At no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. NASA has unique expertise and history in this area, and a clearly demonstrated record of success. NASA will bring that experience to bear in the appropriate way to make sure that commercial crew transportation services are a success both programmatically, and with respect to safety. For example, NASA has a Commercial Orbital Transportation Services (COTS) Advisory Team comprised of approximately 100 NASA technical experts from across the Agency. These experts work with our partners and review partner technical and programmatic progress for each milestone and provide progress assessments to NASA's Commercial Crew Cargo Program Office. Additionally, they participate in all major design reviews providing technical review comments back to our partners. The advisory team provides another method by which NASA gains confidence that our partners will be able to perform their flight demonstrations.

One of the strengths of the COTS venture is that we let the companies do what they do best, that is developing truly unique spaceflight vehicles using innovative processes that aren't available within the Federal bureaucratic framework. We give them requirements that they have to meet and we ensure that they have met those requirements, but we try not to dictate how they meet those requirements. For example, each COTS partner must successfully verify compliance with a detailed set of ISS interface and safety requirements prior to their planned ISS berthing missions. These requirements are imposed on all Visiting Vehicles wishing to visit to the International Space Station (ISS). Both COTS partners are currently working with the ISS program on a daily basis to ensure they meet the ISS visiting vehicle requirements. This also helps to give NASA independent insight into their progress and it builds confidence in their abilities.

With regard to commercial crew, at no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. Simply put, U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so. NASA has unique expertise and history in this area, and a clearly demonstrated record of success in transporting crew. NASA will bring that experience to bear in the appropriate way to make sure that commercial crew transportation services are a success both programmatically, and with respect to safety. At no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. For example, NASA will have in-depth insight of the vehicle design via NASA personnel who are embedded in the contractor's facility. Additionally, NASA will impose strict requirements and standards on all providers that will be carefully evaluated and reviewed at multiple stages before a vehicle system is certified by NASA for crewed flight.

b. Has NASA examined potential cost and schedule impacts of human rating requirements on the commercial launch industry?

A2b. It is not possible for NASA to examine potential cost and schedule impacts at this time, given that the impact of both issues would be individualized based on commercial proposals submitted to NASA. In the same vein, commercial providers have not yet been able to develop cost and schedule baselines because they are waiting for the FY 2011 budget to be approved and for NASA to issue procurement solicitations. Additionally, potential commercial providers will need to see and understand NASA's human-rating requirements which are planned to be complete no later than the end of this calendar year.

c. NASA's own management process for human-rating Ares and Orion took many months and many iterations to develop specific design requirements. What are the agency's plans for developing and publishing human rating standards for commercial launch companies?

A2c. NASA agrees with the Aerospace Safety Advisory Panel (ASAP), which stated, "it is crucial that NASA focus on establishing the certification requirements, a certification process for orbital transportation vehicles, and a process for verifying compliance. The performance and safety requirements must be stated promptly and clearly to enable NASA and non-NASA entities to proceed in the most productive and effective manner possible." Therefore, NASA is working with the commercial partners to clearly articulate human rating processes and requirements that will contribute to the safe flight and safe return of NASA crewmembers on commercial space vehicles. NASA released the preliminary plan using a NASA Request For Information on May 21, 2010. Responses were due on June 18, 2010 and NASA is in the process of reviewing and evaluating the responses. NASA plans to finalize the Commercial Human-Rating implementation plan in time to support an open-competition when NASA pursues the development phase of commercial crew transportation systems." The ASAP plans to complete work on the final human rating plan by the end of the calendar year.

d. Once standards are published, what is the process for applying them to individual launch company systems? Will requirements be tailored for each potential vendor, and how long do you envision such a process to take?

A2d. While NASA is working to develop a new human-rating document that will have a series of generic requirements and standards, it is important to remember that human rating is a process that involves more than a simple set of design requirements; it is not cookie-cutter task. Instead, it is an intricate process of flowdown requirements that are translated into hardware designs; hardware tested against the requirements; design improvements developed and test; vehicles certified for flight; and risks understood with mitigation approaches in place. Additionally, NASA human rates an entire system, including ground elements and operational procedures (fundamentally, anything about the flight or ground system that impacts flight crew/passenger safety), not specific elements of a system. Therefore, additional human-rating plans will have to be developed based on the vehicle design characteristics for each proposed commercial system. Thus, those plans will be developed after selection for developmental funding.

e. Do you expect new space vendors will be required to fly several demonstration missions to validate system safety and reliability?

A2e. NASA does not plan to dictate a specific test program. It is envisioned that the commercial providers will propose a test program and NASA will assess those test programs as part of the Agency's evaluation of proposals and determination of rules.

Q3. Currently the Shuttle program carries an enormous amount of infrastructure and related overhead-costs as part of its budget. If Constellation proceeds, in a similar vein it is likely NASA would also charge related infrastructure and overhead to the program.

a. In order to make an apples-to-apples comparison between Constellation and the commercial crew proposal, where would the costs of NASA's human spaceflight infrastructure and overhead be borne under a commercial crew scheme?

A3a. It is assumed that NASA's human spaceflight infrastructure and overhead would not be borne by commercial providers, unless the providers required a part of that infrastructure. NASA would then have to explore options for providing that infrastructure on a reimbursable basis. NASA does not know what infrastructure will be needed by future commercial crew partners given that we have not yet seen their proposals. Additionally, NASA is continuing to evaluate the Agency's own needs for current facilities and property so as to determine what assets could be used by the new programs and projects outlined in the FY 2011 budget request.

b. If the commercial crew option is approved, going forward how would NASA account for infrastructure and overhead-costs formerly carried under the Shuttle program?

A3b. It is premature for NASA to answer this question at this time. First, NASA does not know what infrastructure will be needed by our commercial crew partners, given that we have not yet seen their proposals as part of a competitive bidding process. Second, NASA is still gathering information to make this decision.

Following the release of the FY 2011 budget request, NASA established a series of study teams to understand the steps (and implications of those steps) that would be needed for an orderly transition to new initiatives outlined in the budget request. The Constellation Transition team, for example, is leveraging expertise from across

the Agency to develop a rapid and cost effective ramp-down plan that will free the resources required for new programs. As part of the early characterization and integrated planning effort, this team has initiated a broad survey of current workforce, contracts, facilities, property, security, knowledge capture, information technology, and other Government agency interface issues to determine what NASA infrastructure and hardware could be used by the new programs and projects.

It is important to note that NASA will be working to eliminate unneeded infrastructure going forward. Part of the reason that the Shuttle was so expensive was because it required a large ground infrastructure to refurbish orbiters, prepare them for flight, and launch them. NASA hopes to be able to replace elements of the Shuttle infrastructure with less costly alternatives.

Q4. With regard to the Administration's heavy-lift launch vehicle proposal, who will build and operate them? Does NASA plan to rely on commercial operators for heavy-lift capabilities in the same manner as commercial crew?

a. Does NASA plan to use commercial providers to launch and operate deep-space long-duration missions?

A4a. As outlined in the FY 2011 budget request, NASA will work with industry (and, to a lesser degree, academia) on research and development activities related to space launch propulsion technologies. This effort will include development of a U.S. first-stage hydrocarbon engine for potential use in future heavy lift (and other) launch systems, as well as basic research in areas such as new propellants, advanced propulsion materials manufacturing techniques, combustion processes, and engine health monitoring. Additionally, NASA will initiate development and testing of in-space engines. Areas of focus could include a liquid oxygen/methane engine and low-cost liquid oxygen/liquid hydrogen engines. This work will build from NASA's recent R&D experience in this area, and the test articles will be viewed as a potential prototype for a subsequent operational engine that would be restartable and capable of high acceleration and reliability. These technologies would increase our heavy-lift and other space propulsion capabilities and significantly lower operations costs—with the clear goal of taking us farther and faster into space consistent with safety and mission success criteria. In support of this initiative, NASA will explore cooperative efforts with the Department of Defense and also develop a competitive process for allocating a small portion of these funds to universities and other non-governmental organizations. This research effort along with many of our new technology initiatives will be coordinated with the broader Agency technology initiative led by NASA's new Chief Technologist. NASA will be aiming to decide the design of a new-heavy lift vehicle by 2015.

Q5. How did the Administration develop its $6 billion estimate for the commercial crew program?

A5. With regard to how the Administration developed its estimate, budget formulation discussions are of a pre-decisional nature and thus cannot be provided for the public record. However, in general, industry input from previous competitions indicate that NASA's available funding could reasonably be expected to provide financial and in-kind support to up to four companies through the development period.

a. Does this budget cover projected development costs for at least two launch companies, and does it assume initial operating costs?

A5a. NASA is still developing the acquisition strategy for commercial crew efforts. However, in general, it would be NASA's preference to award development funding for multiple proposals, thus increasing the likelihood that multiple partners would succeed at developing a commercial crew vehicle. Then after the commercial crew services procurement is released, NASA could potentially select more than one partner to supply those services, thus providing redundancy of capabilities. The $6 billion for commercial crew is for development activities only, not services.

b. What contracting mechanism (e.g. Space Act Agreements, or Federal Acquisition Register-based) does the agency intend to use?

A5b. NASA is still developing the acquisition strategy for commercial crew efforts. Therefore, the Agency has not yet decided which contracting mechanism will be used for the development effort and/or eventual procurement of commercial crew services.

c. What assumptions were made regarding the amount of private equity required to develop each system?

A5c. With regard to the assumptions used by the Administration to develop its estimate, budget formulation discussions are of a pre-decisional nature and thus cannot be provided for the public record.

However, it is important to remember that NASA did not specify a minimum level of cost sharing for Commercial Orbital Transportation Services partners because the Agency felt that it would be inappropriate to prejudge a potential partner's business case. NASA reviewed each proposal as a whole, and assessed each proposal based on its own merits. That included review and evaluation of the type of vehicle system proposed, the development process proposed, as well as market factors such as the potential for other non-Government customers, the amount of investment each company plans to contribute, the company's experience in similar endeavors, etc. No single factor is necessarily more important than another. NASA will likely implement a similar strategy for commercial crew selection.

In addition, it is noteworthy to point out what the Augustine Committee said about the costs of potential crew cargo program: "Comparing the scope of providing a commercial crew capability to the cost of historical programs offers a sanity check. In the existing COTS A–C contracts, two commercial suppliers have received or invested about $400-$500 million for the development of a new launch vehicle and unmanned spacecraft. Gemini is the closest historical program in scope to the envisioned commercial crew taxi. In about four years in the early- to mid-1960s, NASA and industry human-rated the Titan II (which required 39 months), and designed and tested a capsule. In GDP-inflator-corrected FY 2009 dollars, the DDT&E cost of this program was about $2.5–3 billion, depending on the accounting for test flights. These two comparatives tend to support the estimate that the program can be viable with a $5 billion stimulus from NASA."

Q6. Under the Administration's commercial crew proposal, how many privately-financed launches that would be required on an annual basis in order to provide sufficient operating efficiencies to meet NASA's assumed launch and operating costs? Please provide copies of any analyses used to develop these estimates.

A6. These estimates do not exist because they depend on commercial proposals that have not yet been solicited.

Q7. The budget proposal suggests precursor missions to several possible locations, such as the Moon, Mars and Lagrange Points. What are the value of such missions if we've already put robotic spacecraft there; what goals would such missions accomplish, and how do they contribute to NASA's newly-defined mission?

A7. A key contributor to a robust exploration program will be the acquisition of critical knowledge gained through the pursuit of exploration precursor robotic missions. Led by ESMD, this effort will send precursor robotic missions to candidate destinations that will pave the way for later human exploration of the Moon, Mars and its moons, and nearby asteroids.

Like the highly successful Lunar Reconnaissance Orbiter (LRO) and Lunar Crater Observation and Sensing Satellite (LCROSS) missions that captured the Nation's attention last fall, future exploration precursor missions will scout locations, gather key knowledge and demonstrate technologies to identify the most compelling and accessible places to explore with humans and validate potential approaches to get them there and back safely. These missions will provide vital information—from soil chemistry to radiation dose levels to landing site scouting to resource identification—necessary to plan, design and operate future human missions. These missions will help us determine the next step for crews beyond LEO, answering such questions as: Is a particular asteroid a viable target for crewed mission? Do the resources at the lunar poles have the potential for crew utilization? Is Mars dust toxic? Dedicated precursor exploration missions are planned to remain below $800 million in total cost, and many will be considerably less expensive. NASA plans to begin funding at least two dedicated precursor missions in 2011, and to identify potential future missions to begin in 2012 and/or 2013.

Additionally, a new portfolio of explorer scouts will execute small, rapid turnaround, highly competitive missions to exploration destinations. Generally budgeted at between $100 million and $200 million lifecycle cost, these missions will allow NASA to test new and innovative ways of doing robotic exploration of destinations of interest to future human exploration. Selected projects may provide multiple small scouting spacecraft to investigate multiple possible landing sites, or provide means of rapid-prototyping new spacecraft approaches.

Q8. NASA's proposal appears to repudiate the use of solid rocket motors on human-rated launch systems by eliminating the Ares 1 and Ares 5 launch vehicle developments, and by emphasizing research into new heavy-lift hydrocarbon-based

liquid motors. Is the Administration opposed to utilizing solid rocket motors in manned systems, and if so, what is its rationale?

A8. On April 15, 2010, the President laid out the goals and strategies related to the FY 2011 budget request for human exploration of our solar system, including a sequence of deep-space destinations matched to growing capabilities, progressing step-by-step until we are able to reach Mars. In doing so, he also announced that in addition to investing in transformative heavy-lift technologies, he will commit to make a specific decision not later than 2015 on the development of a new heavy-lift architecture. A decision no later than 2015 means that major work on building a new heavy-lift rocket will likely begin two years earlier than under the Constellation Program.

In support of that timeline, NASA will begin heavy lift vehicle system analyses on various launch vehicle concepts to determine the best approach that meets the affordability and reliability figures of merit. The Administration is not opposed to using solid rocket motors. Concept heavy-lift vehicles could include solid rocket motors as well as liquid strap-ons and all concepts will be evaluated during a rigorous systems analysis effort to identify the best configuration to meet the Nation's needs.

Q9. NASA initiated Cargo Resupply Services contracts with potential service providers before any of the COTS systems have been demonstrated. The agency has also made initial payments in the absence of demonstration flights. What is the agency's back-up plan to re-supply ISS if a commercial cargo provider is unsuccessful or goes out to business?

A9. Two companies, Space Exploration Technologies (SpaceX) and Orbital Sciences Corporation have funded Space Act Agreements with NASA as part of the COTS project to demonstrate cargo transportation to ISS. At this time, SpaceX plans to conduct its first NASA demonstration cargo mission supply to ISS in tentatively September 2010, and Orbital Sciences Corporation in June 2011. The actual purchase of cargo services to ISS is being conducted through the separate ISS Commercial Resupply Services (CRS) procurement effort. In December 2008, NASA awarded CRS contracts to SpaceX and Orbital Science Corporation for cargo delivery beginning as early as late 2010. NASA is pre-positioning spares onboard the ISS with the final Space Shuttle logistics flights to provide some margin for delay in commercial cargo services. Beyond that, there is no planned back-up capability for ISS commercial cargo. Timely commercial cargo capability is critical for effective ISS operations. Without commercial cargo capability, the crew size and research operations planned for ISS would need to be reduced.

NASA will also rely on the transportation capabilities of Russia, the European Space Agency (ESA) and Japan to transport cargo to ISS. Russia's Progress vehicle has been providing cargo services to ISS through a contract with NASA. The ESA Automated Transfer Vehicle (ATV) had a successful initial flight to the Space Station in 2008. The Japanese HII Transfer Vehicle (HTV) had a successful initial flight to ISS in 2009. ESA's and Japan's services are provided through barter agreements. It should be noted that NASA does not plan to continue to procure Progress cargo resupply services after 2011, opting instead to rely on U.S. commercial cargo delivery capabilities provided through Commercial Resupply Services contracts.

Q10. The budget proposes an aggressive and expensive spending program ($1.93 billion) to transform the Kennedy Space Center into a modern launch complex, yet the level of detail in the budget justification is vague. For instance, it uses the phrase: "areas under consideration include . . ." There is nothing in the current plan that would launch from the Kennedy Space Center. All the potential commercial providers—ULA, SpaceX, Orbital Sciences—use launch facilities away from KSC. This is true for the Eastern Test Range as well, which is controlled from Cape Canaveral Air Force Station. How did NASA develop the estimate and why at Kennedy Space Center?

A10. The 21st Century Space Launch Complex Program is an initiative to focus on upgrades to the Florida launch range, expanding capabilities to support commercial cargo providers, and transforming KSC into a modern facility. NASA's infrastructure at KSC was originally designed to support the Apollo Program, and was later modified for the Space Shuttle. While this infrastructure has served America well, ongoing concerns about its age have led the Agency to develop this $1.9B range upgrade initiative, based on the longstanding need to modernize integration and operations infrastructure. This effort will be closely coordinated with the United States Air Force (USAF), the Federal Aviation Administration (FAA), and the space user community to develop a requirements plan. This will help ensure that KSC and the larger range shared with Cape Canaveral Air Force Station can continue to serve

as a robust, flexible launch site for civil, military, and commercial missions for decades to come.

NASA currently has a team working with the USAF and FAA on the specific details of the initiative, but the primary focus is to make investments in overall launch and processing operations.

In support of this goal, NASA has revisited previous activities that have addressed future launch/range technologies and capabilities (ex., the *Launch Enterprise Transformational Study*), and formed teams at KSC to prepare an initial list of proposed projects. In addition, Agency representatives have been meeting with commercial and government agencies and organizations to initiate relationships. NASA plans to release a Request for Information (RFI) in the near future to request infrastructure and capabilities needs and associated timelines from potential customers. NASA will also establish Customer Advocates for each entity showing an interest in building relationships and assisting/enabling market entry, recognizing that future commercial users may not be limited to those currently involved in the Commercial Orbital Transportation Services (COTS) and Commercial Resupply Services (CRS) efforts. It is particularly important to begin this effort as soon as possible in order to effectively utilize the time between the retirement of the Space Shuttle and the operational availability of future systems to implement facilities upgrades.

Q11. The five year run-out for the Science Mission Directorate (SMD) clearly favors new spending for Earth Sciences, while the other divisions (Planetary Sciences, Astrophysics, and Heliophysics) grow slowly or are flat-funded. Earth Sciences is proposed to receive a $380M increase in FY 2011 (versus FY 2010 enacted) and $1.8B additional over the five year run-out to accelerate development of new missions recommended in the Decadal Survey. Earth Sciences' share of the SMD budget grows from 30 percent in FY 2009 to 40 percent in FY 2015. Is this an appropriate balance? How will the other science divisions be able to respond to upcoming decadal surveys due out later this year?

A11. The President's FY 2011 budget request for NASA reflects the Administration's commitment to science and innovation broadly and also its commitment to address the challenge of climate change. NASA is essential to the nation's efforts on both fronts. Earth observations from space and the research to turn those data into scientific understanding and practical applications are indispensable to climate change research, mitigation, and adaptation.

The FY 2011 budget request for Earth Science at NASA continues the reverse of a substantial decline in national investment in that program since FY 2000. In fact, the trend set by the FY 2011 budget request will by FY 2015 restore NASA's Earth Science program to the buying power it had in FY 2000. As a consequence of the decline in funding since FY 2000, NASA's fleet of Earth observing satellites—which provide most of the global observations employed in national and international climate change research—has not been refreshed at a rate commensurate with satellite design lifetimes or the need for advances in important science questions. The FY 2010 budget request and Appropriations put the NASA Earth Science missions currently in development on a firm budgetary path to successful completion, and the President's FY 2011 Budget Request enables development and launch of the first Tier of Decadal Survey missions by 2017 and of two Tier 2 missions by 2020. This accomplishes half of the Decadal Survey mission recommendations in the time frame proposed by the National Academies of Science. The funded accelerations of Decadal Survey missions and the addition of key climate continuity measurement missions constitute a robust, responsible, and world-leading capability for climate change research. This is the capability the Nation needs.

With regard to how other NASA Science Mission Directorate divisions will be able to respond to their Decadal Surveys, the schedule for release by the National Academies of Science and the corresponding first budget request to be influenced by those Surveys is as follows:

Survey	Planned Release	First Budget Request Impacted
Astrophysics	August 2010	FY 2012
Planetary Science	Spring 2011	FY 2013
Heliophysics	Spring 2012	FY 2014

NASA will work with the Administration and the Congress to craft an optimal implementation of these Decadal Surveys' recommendations consistent with budget guidelines and constraints that pertain at the time.

Q12. What compelled the Administration to cancel production of Orion? It includes advanced technologies, many of which are identified in NASA's budget plan as candidates for flagship and enabling technology demonstrations, such as closed-loop life support systems, automated rendezvous and docking, and radiation shielding technology. Wouldn't it be more prudent to continue with its design and production instead of a clean sheet approach?

A12. On April 15, 2010, President Obama laid out the goals and strategies for his new vision for NASA. In doing so, he outlined how he wants NASA to restructure the Orion Crew Exploration Vehicle project to design a simpler and more efficient capsule that will be focused on crew emergency escape from the International Space Station. Under the Constellation Program, the Orion crew capsule was intended to house astronauts during their travel to the International Space Station and later missions to the Moon. It also was to be capable of docking at the Space Station for six months and returning crews to the Earth.

Per the President's direction, NASA will build on the good work already completed on the Orion crew capsule and focus the effort to provide a simpler and more efficient design that would provide crew emergency escape from the ISS and serve as part of the technical foundation for advanced spacecraft to be used in future deep space missions. This approach also will preserve a number of critical high-tech industry jobs in key disciplines needed for our future deep space exploration program.

We have put together a formulation team including Headquarters and Center personnel to develop a baseline approach that meets these requirements, balanced with the other priorities proposed in the President's FY 2011 budget request. This team will report to the Administrator on how best to meet these requirements.

The team has been directed to align this work so that it complements, and does not compete with, our commercial crew development effort. In this manner, we will simplify the requirements for potential crew service providers to the ISS by having the restructured Orion effort fulfill the important safety requirement of emergency escape system for astronauts on the ISS. The formulation team will also focus on innovative approaches to oversight, and believe that we can significantly reduce oversight requirements based on lessons learned in previous focused development flight programs. We must accomplish this activity more efficiently and effectively to maintain a healthy funding balance across our exploration priorities. And this will be done without reducing our commitment to safety for crew escape. The crew rescue mission has many fewer requirements than the deep space mission, providing design flexibility and reducing the system's lifecycle cost. Finally, the team must identify how this activity will align with the development efforts proposed in the Flagship Demonstration program as well as our other technology efforts so that investments in these programs can be leveraged to the greatest extent possible.

The funding for this restructuring will come within NASA's top-line request released in February. The out year funding requirements will be refined as part of the President's FY 2012 budget submission.

Q13. We understand NASA leadership and the Augustine Committee received approaches from Constellation contractors to streamline the current program. These approaches offered ways to reduce Constellation program cost and accelerate the schedule. What is NASA's rationale for rejecting this approach—which had fairly mature cost, risk and schedule estimates—in favor of opting for a clean sheet approach with much greater level of unknowns?

A13. Budget formulation discussions are of a pre-decisional nature and thus cannot be provided for the public record.

However, in general, at the highest level, the President and his staff, as well as NASA senior leadership, closely reviewed the Augustine Committee report, and came to the same conclusion as the Committee: The Constellation Program was on an unsustainable trajectory. They determined that, given the current budget environment, Constellation's funding needs would have required terminating support of the International Space Station in 2016 and NASA would not have had sufficient resources to significantly advance the state of the art in the technology areas that would be needed to enable lowering the cost of heavy-lift access to space, and developing closed-loop life support; advanced propulsion technology; and radiation protection and other technologies on a faster schedule. The President determined that what was truly needed for beyond LEO exploration was game-changing technologies; making the fundamental investments that will provide the foundation for the next half-century of American leadership in space exploration. At the same time, under

the new plan, NASA would ensure continuous American presence in space on the ISS throughout this entire decade, re-establish a robust and competitive American launch industry, start a major heavy lift technology program years earlier, and build a technological foundation for sustainable beyond-LEO exploration of our moon, near-Earth asteroids, Lagrange points, and ultimately Mars.

Questions submitted by Representative Gabrielle Giffords

Q1. As you know, the Constellation Program's Ares crew launch vehicle is being designed to meet Columbia Accident Investigation Board and Astronaut office requirements that the Shuttle's replacement be at least 10 times safer than the Space Shuttle.

a. Will NASA require that commercial crew transportation alternatives be 10 times safer than the Shuttle? If not, why not?

A1a. Safety is and always will be NASA's first core value, so we will provide significant oversight over any commercial venture. Simply put, U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so.

To date, NASA has not specified a Loss of Crew requirement for commercial crew transport, but will do so as part of the acquisition strategy process currently in progress. However, we intend for Commercial Crew to be much safer than the Space Shuttle.

b. How will NASA verify that selected commercial crew alternatives selected meet the safety standard set by NASA?

A1b. NASA is in the process of developing a plan that supports the development of commercial crew transportation providers to whom NASA could competitively award crew transportation services. NASA released the preliminary plan using a NASA Request For Information on May 21, 2010. Responses were due on June 18, 2010 and NASA is in the process of reviewing and evaluating the responses. NASA plans to finalize the Commercial Human-Rating implementation plan in time to support an open-competition when NASA pursues the development phase of commercial crew transportation systems.

As noted earlier, U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so. Therefore, we will establish strict oversight processes to ensure that our safety standards are met.

At no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. NASA has unique expertise and history in this area, and a clearly demonstrated record of success. NASA will bring that experience to bear in the appropriate way to make sure that commercial crew transportation services are a success both programmatically, and with respect to safety.

Q2. During your remarks introducing the FY 2011 budget request, you referenced the commercial space industry's claim that as many as 5,000 new jobs would be created. What is the basis for this estimate and has NASA independently verified the likelihood of that claim? What is the nature of the jobs created?

A2. The 5,000 figure should be considered a low end initial estimate. The Tauri Group, using U.S. Bureau of Economic Analysis model Regional Input-Output Modeling System (RMIS II) estimated an overall average of more than 11,800 jobs per year over five years with a peak of 14,200 jobs in FY 2012. NASA is trying to reduce the cost needed to support commercial spaceflight and believes that these approximate contractor workforce levels will be reflected in their proposal submissions.

Q3. The Augustine Committee report pointed out the importance of sustaining critical national skills such as the capability to produce solid rocket boosters when it stated: "Special attention needs to be devoted to assuring the vitality of those portions of the workforce that represent critical and perishable skills that are unique to the space program. One example is the design and manufacturing of very large, solid propellant motors."

a. To what extent do the Administration's proposed plans address this workforce issue?

A3a. NASA is very cognizant of the workforce and industrial base issues mentioned in Section 9.3 of the Report, *NASA Management Challenges*. The management challenge was well stated, in that "only a modest fraction of jobs generally fits the 'critical, perishable, and unique' criterion." The proposed FY 2011 budget invests heavily in advanced technology, which will allow NASA to invest in the critical skills associated with these technologies. NASA will work towards a no later than 2015 decision on the design of a heavy-lift launch vehicle. While a key focus of early R&D

will be on a hydrocarbon engine, a range of design options will be considered. NASA will provide special attention to identifying those critical skills required to enable this range of design options.

NASA has been in the process of planning for the transition of its workforce after the retirement of the Space Shuttle since 2004. While the proposed transition away from the Constellation Program would change the array of projects available to workers moving forward from Shuttle, many of the transition practices and Federal/state/local networks set up in affected areas will be applicable to this new transition challenge. These practices have included an effort to ensure that critical skills are retained by providing a career path to meaningful follow-on work in other programs, maintain NASA's quality workplace by providing a collaborative and creative environment, and support career development and learning opportunities. NASA is committed to transitioning the key Space Shuttle civil servant workforce to other Agency programs as necessary using tools such as workforce synergy, matrixing, detailing, and retraining. In addition, Centers identify opportunities for the placement of employees with needed skills in other organizations.

To ease the transition for workers dislocated while the new space strategy is being implemented, the President has dedicated up to $100M of the funds requested for the Constellation transition to promote economic growth and job creation. At least $40M of those monies will be dedicated to transforming the regional economy around the Kennedy Space Center (KSC) and prepare its workforce for these new opportunities. On May 3, the President identified a high-level team of senior officials from the Departments of Defense, Commerce, and Labor as well as NASA and the White House to develop a plan for regional economic growth and retraining dislocated workers to pursue new work opportunities. The team will report its recommendations to the President by August 15.

Currently, NASA plans to provide an update of its *Workforce Transition Strategy* to Congress last this year. In addition, on June 28, the Agency provided Congress with more qualitative update on ongoing transition efforts since last summer.

b. Have any industrial base impact assessments been performed by NASA or the administration on the potential cost increases to other government agencies or loss of industrial base capabilities if systems or materials that are critical to national security are no longer procured by NASA? If so, please provide the assessment to this Committee.

A3b. NASA has not conducted any formal assessments in these areas. However, NASA worked with Defense officials to develop a plan to maintain the intellectual and engineering capacity, including key workforce skills, to support next-generation rocket motors as needed. The task force is co-chaired by the Office of the Secretary of Defense's Acquisition, Technology, and Logistics office and NASA and includes representatives from the Department of Defense, NASA, the Missile Defense Agency, the Air Force, the Army, and the Navy. This DOD report, entitled "SRM Industrial Base Interim Sustainment Plan" was released to Congress on June 23, 2010.

Q4. You testified that "While . . . we cannot provide a date certain for the first human visit, with Mars as a key long-term destination we can identify missing capabilities needed for such a mission and use this to help define many of the goals for our emerging technology development." When can the Committee expect to see a technology roadmap for Mars? When will NASA have a plan that outlines how the new technology initiatives will address the goals in a Mars technology roadmap?

A4. The President's FY 2011 budget request outlines an innovative course for human space exploration, but does not change our goal—extending human presence throughout our solar system. NASA's exploration efforts will focus not just on our Moon, but also on near-Earth asteroids, Lagrange points, and ultimately Mars. The President has voiced his commitment to sending humans to orbit Mars by the mid-2030s with a landing on Mars to follow. While we cannot provide a date certain for the first human visit, with Mars as a key long-term destination we can identify missing capabilities needed for such a mission and use this to help define many of the goals for our emerging technology development. The research and technology investments included in this budget describe the many near-term steps NASA will be taking to cultivate the new knowledge and breakthrough capabilities required for humans to venture beyond low-Earth orbit (LEO) to stay.

NASA's Exploration Systems Mission Directorate (ESMD) will lead the Nation on this new course of discovery and innovation, providing the technologies, capabilities and infrastructure required for sustainable, affordable human presence in space. Many of these capabilities have been recommended consistently for at least 24 years in national level reports of committees and commissions addressing future human

space exploration. ESMD's investment in gaining critical knowledge about future destinations for human exploration, as well as transformational technology development and demonstration will serve as the foundation of NASA's ongoing space exploration effort, broadening opportunities for crewed missions to explore destinations in our solar system that we have not been to before. We have not sent people beyond low-Earth orbit in 38 years, and this budget gives us the great opportunity to focus on scouting and learning more about destinations to further explore our solar system and to develop the game-changing technologies that will take us there. It is important that we pursue these objectives to continue leading the world in human space exploration.

Pursuant to the President's proposed new course, NASA has initiated planning activities to be able to effectively and efficiently implement these new activities in a timely manner upon Congressional enactment of the FY 2011 budget. In April, NASA outlined for the Committee the Agency's planned major program assignments across the Agency's Centers for new or extended activities proposed as part of the President's FY 2011 budget request. These planned assignments build on the deep knowledge and expertise that NASA has built up over five decades, recognize the wealth of experience, commitment, and expertise resident at the NASA Centers, and expand upon the strengths at each Center. Additionally, following the release of the FY 2011 budget request, NASA established study teams within ESMD to ensure we understand the steps (and the implications of those steps) that would need to be taken for an orderly transition of the Constellation Program and to plan for the implementation of the new initiatives in the Exploration program. The work undertaken by these teams is a necessary part of that planning.

NASA is taking prudent steps to *plan* for the new initiatives included in the FY 2011 budget request, including Requests for Information (RFI), workshops, and preliminary studies.

NASA is eager to seek external input from industry, academia, and other partners, and plans to accomplish this via a series of RFIs and industry workshops conducted this spring and into the summer. Doing so will ensure that NASA receives important feedback from our space partners before it begins to finalize its implementation plans for the proposed technology demonstrations and human spaceflight systems development activities that will be supported by the FY 2011 budget, once approved by Congress. During CY 2010, NASA plans to issue a series of program formulation documents seeking input from the broader space community.

Finally, NASA also has established the Human Exploration Framework Team (HEFT) to serve as a cross-Agency planning activity. The team is being led by the Exploration Systems Mission Directorate and staffed with technical leaders from across NASA Centers. The team is focused on developing and reviewing the integrated set of requirements and technologies required for future human spaceflight missions to many destinations, including Mars. As part of its broad integration charter, HEFT will develop implementation recommendations on the performance and pacing requirements for the technologies needed for future human exploration missions using "design reference missions," or DRMs. These DRMs will be the basis for validating capabilities and missions for five, 10-, and 15-year horizons, with milestones including crewed missions beyond the Moon into deep space by 2025, sending astronauts to an asteroid, and eventually landing on Mars. NASA expects to have initial products from the HEFT team this summer.

Q5. Who will assume the liability for accidents involving commercial space transportation vehicles carrying U.S. government employees or carrying researchers paid with government funds?

A5. NASA is still developing the acquisition strategy for commercial crew efforts. Therefore, it is premature to specifically address how liability will be addressed in connection with the Agency's acquisition of crew transportation services. The answer to this question may depend on what type of contract the Agency chooses to utilize to develop and eventually procure crew transportation services, the role that any licensing or regulatory agency may play in Agency crew transportation services, and the availability of private insurance for these services.

Q6. Some emerging "commercial" companies have indicated publicly that they intend to keep all development and production efforts internal to "reduce cost." Under this plan, would the "commercial" providers be required to comply with the same small/small disadvantaged business requirements as the current government contractors? What effect would relaxing that requirement have on the thousands of small businesses who depend on government programs to remain viable? Currently NASA contractors are required to foster economic development by partnering with small businesses, specifically, small disadvantaged businesses,

historically black universities, and minority institutions. Would these same requirements exist for commercial suppliers under the new program?

A6. Although NASA is still developing the acquisition strategy for commercial crew efforts, NASA will ensure that once final, this effort will take into account all applicable laws and regulations. However, it is premature to specifically address how requirements for small and disadvantaged businesses will apply to the Agency's commercial crew efforts because the answer to that question will depend on what type of contract the Agency uses to develop and eventually procure commercial crew services.

Q7. Approximately how much of the budget of the Constellation program pays for facility operations and other overhead functions that are shared with other programs? If the Constellation program is cancelled as the Administration is proposing, how will these shared costs be reallocated to other programs? Which programs will be affected? Please provide the committee with an estimate of how much additional cost will be borne by each affected program.

A7. NASA's budget has discrete appropriations for Center Management and Operations and Agency Management and Operations, so the "facility operations and other overhead functions that are shared with other programs" paid for by Constellation are limited to human space flight programmatic functions shared with the Shuttle program and to some extent the International Space Station program.

Since much of the unaffordability issue that led to the decision to transition away from Constellation is due to absorbing legacy facilities, capacity and costs, NASA has substantial incentive to reduce human spaceflight facilities and overhead costs rather than pass them on to future programs. NASA is in the process of assessing what infrastructure and hardware would be needed by the new programs and projects outlined in the FY 2011 budget. Also, NASA does not know what infrastructure will be needed by our commercial crew partners, given that we have not yet seen proposals from a competitive bidding process.

Q8. According to the NASA Fiscal Year 2011 Budget Estimates, one of the potential missions mentioned for the Precursor Robotic Missions program is a "lunar mission to demonstrate tele-operation capability from Earth . . . including the ability to transmit near-live video to Earth." At the same time, the Google Lunar X Prize website states that "the Google Lunar X Prize is a $30M competition for the f rst privately funded team to send a robot to the moon, travel 500 meters and transmit video, images and data back to Earth." What is the added value of NASA's proposed mission?

A8. One of the first two candidate missions being considered as part of the proposed Exploration Precursor Robotic Program is a mission involving a lunar lander and a robotic rover. Such a mission would help to verify the findings of NASA's Lunar Reconnaissance Orbiter (LRO) mission, which launched in June 2009. The LRO mission has a one-year primary mission to develop a highly detailed, topographic map of the lunar surface—the highest resolution and most comprehensive data set ever returned from the Moon.

While the LRO mission orbited the Moon, a lunar precursor mission with a robotic rover would allow NASA to have a vehicle on the lunar surface that would be used to verify LRO observations from space (topography, lighting, volatiles, surface radiation, etc.). The lander would also provide risk reduction of future human spaceflight through demonstrations of important technologies (ISRU, autonomous hazard avoidance and landing) and enhance experience with surface operational concepts. Additionally, the landers will be equipped with high definition video cameras sending exciting video back to Earth that will help inspire the next generation of engineers and scientists.

To some it may appear that this proposed mission is similar to the Google X–Prize. However, this comparison is inaccurate for several reasons, including:

- While the Google X–Prize is designed to foster commercial capability in the realm of space exploration, provide a venue for new commercially-developed technologies, and to stimulate public interest, NASA's precursor mission will reduce risk through measurements of hazards and demonstrations of important technologies, and enable and inform human exploration objectives, while also seeking opportunities for partnerships and engagement with the public.
- With regard to mission, Google X–Prize participants will attempt land a rover on the lunar surface, travel 500 meters over the surface and then send back video and data. (There are additional "bonus" awards for longer durations, longer distances, imaging of Apollo sites, etc.) In contrast, NASA's precursor mission will include a payload to address important investigations as a pre-

cursor to enable and inform human exploration. Although the candidate mission payload and its selection process are still being defined, NASA currently intends for the payload to include a larger complement than just a camera. Candidate investigations may include radiation measurements to enhance the safety of future human explorers, in situ resource utilization experiments and related measurements such as volatile mass spectroscopy or dynamic albedo neutron spectroscopy, to enhance exploration sustainability.

- The low-cost Google X-prize missions may be limited in their reach on the Moon's surface, and unlikely to be capable of reaching many high value destinations such as the lunar poles.

While different, NASA's mission and the X–Prize also could be complimentary. Therefore, NASA looks forward to capitalizing on any capabilities developed by X–Prize competitors.

Q9. The NASA Authorization Act of 2008 directed NASA to establish an intra-Directorate, long-term technology development program for space and Earth science within the Science Mission Directorate for the development of new technology and structured to include competitively awarded grants and contracts. To date, such a program has not been established. Given the enormous amounts of taxpayer dollars that the Administration is requesting to support NASA-sponsored advanced technology developments, what is the rationale for not following the direction Congress established in the 2008 law?

Background: The relevant portion of the 2008 NASA Authorization Act says:
SEC. 501. TECHNOLOGY DEVELOPMENT.

The Administrator shall establish an intra-Directorate long-term technology development program for space and Earth science within the Science Mission Directorate for the development of new technology. The program shall be independent of the flight projects under development. NASA shall have a goal of funding the intra-Directorate technology development program at a level of five percent of the total Science Mission Directorate annual budget. The program shall be structured to include competitively awarded grants and contracts.

A9. NASA believes the approach to managing and funding technology development reflected in the President's FY 2011 Budget Request, coupled with technology programs already in existence in the Science Mission Directorate (SMD), meet and exceed the goals of the NASA Authorization Act of 2008. The technology goals stated in the Act and NASA's approach to achieve them are:

Development of new technologies: Future science objectives and missions recommended by National Academy of Sciences decadal surveys received or underway (as well as mission concepts to be proposed in response to future competitive solicitations) will require technological capabilities beyond those in hand to day to make them possible, affordable, or both. These include: drilling, sample handling, ascent, rendezvous, and return for Mars Sample Return; in-space propulsion and radiation hardening for future outer planets missions; precision maneuvering and control for multi-spacecraft astronomical observatories; and multi-frequency lasers and high-precision lidars for three-dimensional profiling of changes in Earth's atmosphere and surface.

NASA's SMD is investing in these and other technologies, guided by the decadal surveys and science community's expression of future needs. SMD's investment is focused on maturing specific technologies to the point where they can be successfully incorporated from a technical risk standpoint into instrument and mission proposals. NASA's new Office of the Chief Technologist (OCT) is developing plans to implement technology developments that address multiple NASA Mission Directorates and or other government agencies needs and run the full range on the TRL scale from advanced system concepts to flight demonstrations.

Independent of flight projects in development: While some flagship-class missions such as the James Webb Space Telescope include technology development needed for the success of the mission in the formulation stage of the project, much of SMD's technology development occurs in programs separate from flight projects. For example, the Earth Science Technology Program comprises the Instrument Incubator Program, the Advanced Technology Initiative program, and the Advanced Information System Technology program all upstream-and independent-from specific flight projects. The Earth Science Technology Office has examined the Earth Science and Applications from Space decadal survey and is targeting its solicitations and technology investments to enable the missions identified in that survey. The Planetary Instrument Definition and Development research element in SMD's Planetary Science Division, the Living with a Star Targeted Research and Technology research

element in SMD's Heliophysics Division, and the Strategic Astrophysics Technology research element in SMD's Astrophysics Division do similarly. The Agency-level technology program proposed in the President's FY 2011 Budget Request is designed to enable future missions with advanced technologies outside of and in advance of the specific benefiting flight projects.

Funded at a level of five percent of SMD budget: The sum of SMD technology investments solicited through the Research Opportunities in Space and Earth Sciences (ROSES) omnibus solicitation, including the focused technology programs named above and suborbital research programs exceeds five percent of the SMD budget. When adding the technology development activities within flight projects—many of which will also benefit future flight projects—the total SMD technology investment approaches ten percent. While the portion of the FY 11 proposed Agency-level technology program that will benefit SMD is yet to be determined, at a planned investment level on the order of $1 billion annually, the positive benefit to future SMD missions is likely to be substantial.

Include competitively awarded grants and contracts: The SMD technology programs named above consist largely of competitively awarded grants and contracts. As with all SMD solicitations, these are open to academia, industry, other government labs, and other sources. In ROSES 2010, open competitive solicitations planned for technology development include:

- Instrument Incubator;
- Advanced Component Technology;
- Advanced Information System Technology;
- Living with a Star Targeted Research and Technology—Strategic Capability;
- Mars Instrument Development;
- Mars Technology;
- Planetary Instrument Definition and Development;
- Astrobiology Science and Technology for Instrument Development;
- Astrobiology Science and Technology for Exploring Planets;
- In-Space Propulsion;
- Astrophysics Research and Analysis;
- Strategic Astrophysics Technology.

The proposed technology program managed by the NASA's OCT will also employ open, competitive solicitations as one mechanism to stimulate and garner the best ideas from the nation's technical experts.

NASA's SMD will work closely with the OCT to coordinate activities and enable SMD to benefit from OCT's investments. The SMD Associate Administrator or designee will be a member of OCT-chaired NASA Technology Executive Council, and SMD has identified a Chief Technologist within SMD to coordinate SMD technology programs and the SMD interface to OCT.

Q10. The proposed FY 2011 request includes $429 million and a total of about $2B over five years for a 21st Century Space Launch Complex. What was the process used to identify this space launch complex as a priority for modernization as opposed to other aging NASA facilities?

A10. The 21st Century Space Launch Complex Program at KSC is an initiative to focus on upgrades to the Florida launch range, expanding capabilities to support commercial providers, remediating environmental issues, and transforming KSC into a modern facility. The decision to focus on the Florida range was founded in part on the President's budget that enhances and grows our Nation's commercial space industry. Additionally, there has been a growing concern relative to the support of national security payload processing and launch capabilities with an aging launch infrastructure that this initiative addresses. NASA's infrastructure at KSC was originally designed to support the Apollo Program, and was later modified for the Space Shuttle. While this infrastructure has served America well, the retirement of the Shuttle presents a once-in-a-generation opportunity to use this $1.9B range upgrade initiative to modernize the nation's primary launch complex. This effort, based on the longstanding need to modernize integration and operations infrastructure, will be closely coordinated with the United States Air Force (USAF), the Federal Aviation Administration (FAA), other national security entities, and the commercial space user community in the coming weeks to develop a requirements plan. This will help ensure that KSC and the larger range shared with Cape Canaveral Air Force Station can continue to serve as a robust, flexible launch site for civil, military, and commercial missions for decades to come.

NASA is working preliminary planning with commercial, the USAF and national security partners on the specific details of the initiative, but the primary focus is to make investments in overall launch and processing operations.

a. Given the Administration's proposal to cancel the Ares launch vehicle program and indefinitely defer development of a heavy-lift launch vehicle, is there any urgent requirement for this modernization initiative and, if so, what is it?

A10a. For some modifications, it is important to begin this effort as soon as possible in order to effectively utilize the time between the retirement of the Space Shuttle and the operational availability of future systems to implement facilities upgrades. Other modifications, such as enhancing payload processing capabilities, will be helpful for our on-going robotic missions and therefore are beneficial as soon as they can be implemented. NASA has revisited previous activities that have addressed future launch/range technologies and capabilities (ex., the *Launch Enterprise Transformational Study*), and formed teams at KSC to prepare an initial list of proposed projects. In addition, Agency representatives have been meeting with commercial and government agencies/organizations to initiate relationships. NASA plans to release a Request for Information (RFI) in near future to request infrastructure and capabilities needs and associated timelines from potential customers. NASA will also establish Customer Advocates for each entity showing an interest in building relationships and assisting/enabling market entry, recognizing that future commercial users may not be limited to those currently involved in the Commercial Orbital Transportation Services (COTS) and Commercial Resupply Services (CRS) efforts.

b. What is the specific breakdown of the $429M requested for this initiative for FY 2011 by proposed task?

A10b. While NASA is reviewing the specific tasks that would be funded by the $429M requested for this initiative in FY 2011, in order to achieve low-cost, routine, and safe access to space, the Agency must invest in capabilities and technologies that address:

- Manufacturing and Processing;
- Launch Operations;
- Interoperability among Spaceports and Ranges, including common systems and open architectures;
- Range Tracking and Surveillance Capabilities and Technologies that protect the public, but also provide test and evaluation capabilities that support an engineering environment;
- Common Communications Architectures;
- Flexible System Telemetry that are Internet Compatible;
- Weather Prediction and Decision-Making Models;
- Inspection and System Verification Capabilities and Techniques;
- Transportation, Handling, and Assembly Capabilities; and
- Supply Chain Management.

Not all of these elements would necessarily be addressed in FY 2011, but the Agency is working with its commercial, USAF, and other national security partners to develop a plan forward with respect to specific tasks and timeframes. Below is a list of candidate projects that are being considered for FY 2011 and beyond. NASA will work to ensure that Congress is kept informed as further details are developed.

KSC Modernization Potential Projects

- Construction of public access to the Space and Life Sciences Laboratory (SLSL) to allow for integrated business partnerships and other private sector support facilities in the area
- Exploration Park IT/Telecommunications Services
- Modernization of Launch Control Facility
- Integrate information technology advancements
- Renovation of Vehicle Assembly High Bay areas
- Modification of existing launch Pad (LC–39B) and associated systems

CCAFS Range Modernization Potential Projects

- Development of Range/Customer interface software tool
- Development of NASA/CCAFS integrated transmission system

- Partner with USAF on Launch Enterprise Transformation Study
- Gaseous Nitrogen infrastructure on CCAFS
- Replace 50MHz Doppler Radar Wind Profiler

Environmental Remediation/Technology Potential Projects

- Remediation and Cleanup, permitting and compliance, and climate change adaptation that address current issues and enable growth and modernization to follow
- KSC-wide Land Use Controls Elimination
- Dune Restoration
- Energy projects that reduce overall operating cost and comply with reduction Executive Orders
- R&D that contribute to environmentally responsible ground operations

Payload Processing Potential Projects

- Astrotech Payload processing capacity improvement
- Provide supplemental funding to complete the 4th Eastern Processing Facility bay (CCAFS) for shared use by multiple NASA and NRO programs
- CCAFS Area 59 Satellite Processing Facility
- Provide a standardized payload transporter and supporting infrastructure
- Upgrades to the Multi-Payload Processing Facility to allow hazardous and compartmentalized processing on KSC
- Upgrade Space Station Processing Facility for non-hazardous civil, commercial and government/national security payload processing

Questions submitted by Representative Pete Olson

Q1. During testimony before the House Appropriation Subcommittee on Commerce, Justice, Science and Related Agencies on March 23, 2010, Administrator Bolden asserted the Ares 1 would cost $1.6 billion per flight and the program would cost approximately $4.5 billion per year.

a. What is the basis of these cost estimates'? Please provide the documentation that supports these estimates.

A1. NASA recognizes that there is often confusion with regard to publicized flight cost estimates associated with the Ares projects, largely because those estimates often include different assumptions. One key point of confusion, for example, comes from the fact that the Ares I and Ares V share significant fixed costs for vendor production base and sustaining engineering, since both vehicles would use similar solid rocket boosters, upper stage engines and avionics. Therefore, there are two ways to consider the cost of an Ares I flight—one, where the Ares I fixed costs are lower because it is assumed that certain fixed operational costs would be shared with the Ares V, and another, where the Ares I fixed costs are higher because the current shared-cost scenario is not assumed.

In general, NASA does not budget by flight, but rather by fixed and marginal costs expected on an annual basis. The fixed cost (i.e. prime and non-prime support labor, costs of facilities) would be the cost that must be incurred whether one rocket or multiple rockets are built. In other words, the fixed cost is absorbed by the first annual flight and is not counted again that year. The marginal costs, on the other hand, are those costs that can be cleanly attributed to the production of one unit, and that cost is generally the same, unit by unit. So for each subsequent annual flight, NASA adds on only the marginal cost, given that the fixed cost has already been absorbed into the first. It is important to note, however, that NASA's formula of calculating the cost of an Ares I flight (or subsequent annual flights) does not include the project costs for the associated support elements, such as ground operations, mission operations, Extra Vehicular Activity and program integration. Those costs would be book kept under their respective project lines.

With regard to the cost per flight, NASA currently estimates that both Ares I and Orion account for $69M each in marginal costs for a flight unit, thus totaling $138M in marginal costs for each flight since each flight would be assumed to have a capsule and a rocket. However, the fixed cost per flight would vary based on whether Ares I and Ares V shared operational costs were assumed.

For example, the FY 2010 budget request assumed that Ares I and Ares V would share some operational costs—approximately $700M per year, which would, in turn,

equate to lower fixed costs for the Ares I. Therefore, under that scenario—which was provided to Congressman Aderholt's staff in November 2009—the total cost for the first flight would be $919M ($781M in fixed cost plus $138M in marginal costs) with each subsequent flight costing $138M extra in marginal costs, as outlined in the chart below:

Estimated Annual Operations Fixed and Marginal Costs for Ares I and Orion With Ares I and Ares V Sharing Operational costs

	FY08 $s M
Fixed Costs (Ares I and Orion)	781 *
Marginal Cost for 1st flight	138
Total cost for first flight	919
Marginal Cost for 2nd flight	138
Total cost for 2 flts per year	1,057
Marginal Cost for 3rd flight	138
Total cost for 3 flts per year	1,195

* Note: This assumes Ares I fixed costs are shared with Ares V. It also excludes fixed costs for supporting elements.

However, if the assumption is that Ares I and Ares V would *not* share operational costs, it is equally true to say that the cost of an Ares I flight is nearly $1.6B. Under this scenario, all operational costs would be carried by Ares I—which would account for an approximate $700M increase in the fixed cost for Ares I. Thus, under this scenario, the total cost for the first flight would be $1.461B in fixed cost plus $138M in marginal costs, with each subsequent flight costing $138M extra in marginal costs, as outlined in the chart below:

Estimated Annual Operations Fixed and Marginal Costs for Ares I and Orion With Ares I Carrying All of the Operational costs

	FY08 $s M
Fixed Costs (Ares I and Orion)	1,461 *
Marginal Cost for 1st flight	138
Total cost for first flight	1,599
Marginal Cost for 2nd flight	138
Total cost for 2 flts per year	1,737
Marginal Cost for 3rd flight	138
Total cost for 3 flts per year	1,875

* Note: This assumes Ares I fixed costs are not shared with Ares V. It also excludes fixed costs for supporting elements.

NASA is unsure about the source of the number cited since there are similar figures often used, albeit with different assumptions included in each. However, judging by the hearing exchange, it seems the question derived from a discussion about how much it would cost to keep the Ares project running in FY 2011. If that is indeed the question, then, in order to understand the cost of the Ares I project, it is important to understand the full cost of the Constellation Program. Based on the FY 2010 budget request, NASA estimates it would cost $5.4B to continue the full Constellation Program, including Ares I and Orion development and testing, and all supporting elements (ground processing facilities, mission control, program integration etc.) which together would lead to an Initial Operational Capability for two crewed flights to the International Space Station per year. Of the $5.4B figure, the Ares I project was estimated to cost $2.1B, with Orion costing $1.8B, and other Constellation supporting elements equating to about $1.5B.

The FY 2011 budget request transitions away from the Constellation Program. Therefore, under this assumption, if NASA were required to continue only the Ares

I project, the cost to do so would be about $4–4.5B—which would pay for the project elements and also include the full cost of *all* supporting elements outlined in the FY 2010 budget request, such as ground processing facilities, mission control, program integration etc. Without these supporting elements, the Ares I could not fly. This scenario also assumes that Orion would be cancelled, so close-out costs for Orion were factored into this estimate. (Note: Without an Orion, this scenario would not provide an IOC capability.) Additionally, it is important to remember that under the FY 2010 budget request and its five-year runout, the Constellation Program as a whole was expected to begin ramping up work in FY 2011, and in doing so, was expected to also begin assuming additional Shuttle infrastructure and workforce costs in addition to increased development costs, currently estimated to be $600–700M. Therefore, those costs are factored into the continuation cost estimate.

Q2. During his speech at the Kennedy Space Center on April 15, 2010, president Obama directed NASA to begin developing a rescue vehicle using the Orion crew capsule.

a. What is the cost estimate for such a development?

A2a. NASA is currently assessing what it will take to develop an emergency crew return derivative of the Orion spacecraft, per this new direction from the President's April 15th address. The goal is to be as cost effective as possible, taking maximum advantage of the work performed to date on Orion design, development, and testing while deferring further work on systems that would provide capabilities not needed for emergency crew return. Once the cost estimate is finalized, NASA will submit a revised FY 11 budget request to the Congress.

b. Where in the budget will the funding come from?

A2b. It is not yet determined precisely where the funding will come from. The sources will be dependent on the magnitude of the estimated cost, which is still in work. The total proposed budget for NASA did not change with this new direction to develop an Orion emergency crew return module. Therefore, its costs will need to be offset by reductions to other line-items. When a funding plan is finalized, NASA will submit it to the Congress.

c. What previous programs will be displaced by this new change?

A2c. NASA has not yet determined precisely where the funding will come from. The sources will be dependent on the magnitude of the estimated cost, which is still in work. The total proposed budget for NASA did not change with this new direction to develop an Orion emergency crew return module. Therefore, its costs will need to be offset by reductions to other line-items. When a funding plan is finalized, NASA will submit it to the Congress.

d. How would such a vehicle get to the International Space Station?

A2d. The Orion crew emergency return module will launch un-crewed as a payload on a yet-to-be determined expendable launch vehicle. The Orion will then utilize autonomous rendezvous and docking technology similar to the European Space Agency's Automated Transfer Vehicle (ATV) and Russian Progress spacecraft, or autonomous rendezvous with Remote Manipulator System capture/berthing such as the Japanese HII Transfer Vehicle (HTV) and as planned for the NASA COTS cargo vehicles.

e. Given that NASA will have to use the Russian Soyuz capsule for crew access to the International Space Station, what additional capability would an Orion-based crew lifeboat provide?

A2e. As part of the President's new plan for NASA, the development work already performed on this capability will be re-oriented to meet the important safety requirement of providing stand-by emergency escape capabilities for astronauts on the Space Station. We will be able to launch this vehicle within the next few years, enabling an American crew escape capability that will increase the safety of our crews on the Space Station, reduce our dependence on foreign providers, and simplify requirements for other commercial crew providers. This effort will also help establish a technological foundation for future exploration spacecraft needed for human missions beyond low Earth orbit.

Q3. How will NASA flight-qualify a human-rated Orion-based crew rescue vehicle?

A3. Safety is and always will be NASA's number one core value. Therefore, NASA will ensure that any vehicle that carries U.S. astronauts meets stringent safety standards.

The preliminary qualification plan for the Orion emergency return module will be determined as part of the cost estimating exercise which is currently in process. The qualification plan will meet applicable human rating requirements for the emergency crew return mission. As with the baseline Orion project, the emergency return variant will be qualified using a combination of model-based analysis and ground testing. Currently, flight testing will be done as part of its operational development. The Orion emergency crew return module will be fully certified before any potential use for ISS escape.

Q4. If Congress does not appropriate the $312M requested in the FY 2011 budget for commercial cargo, will that in any way effect the ability of the COTS providers to fulfill the current, existing obligations of the CRS contract?

A4. The $312M would be utilized to help improve the chance of mission success of NASA's current commercial cargo program by adding or accelerating the achievement of already-planned milestones, adding additional capabilities, or tests that may ultimately expedite the pace of development of cargo flights to the ISS. The funds could be utilized to add additional tests or capabilities for risk reduction purposes or to evaluate the benefits of accelerating hardware fabrication and assembly of long-lead items.

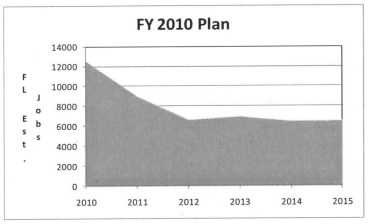
Both the COTS and CRS contractors are legally required to meet their milestones and deliver services under the terms of their agreements.

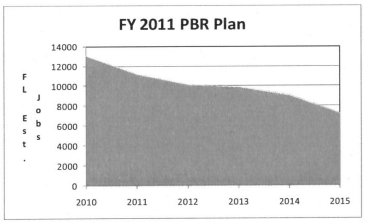
It should be noted that on June 29, 2010, the Summary of NASA-Related Provisions from the FY 2011 Senate-Reported Commerce, Justice, Science and Related Agencies Appropriations Bill included the following wording, "The major feature of the House Appropriations Subcommittee markup is that it 'fences' all Exploration funds, with the exception of $306M for Commercial Cargo, 'subject to enactment of legislation authorizing human spaceflight activities in FY 2011.'"

Q5. During his speech at the Kennedy Space Center on April 15, 2010, president Obama asserted his plan would add more than 2,500 jobs along the Space Coast in the next two years compared to the plan under the previous administration.

a. What is the basis for this assertion? Please provide the supporting documentation for this analysis.

A5. NASA has committed to provide Congress an updated Workforce Transition Strategy by August 2010. That document will fulfill NASA's statutory requirement to provide detailed workforce estimates to the Congress. The basis for the above assertion is work done in preparation for that public document. The specific number used was derived from the work that was done by NASA's Office of Independent Program and Cost Evaluation, but used different assumptions.





The FY 2010 plan, which included retirement of the Space Shuttle and little need for build-up of workforce for Constellation launches, shows a drop of nearly 7,000 in total workforce demand in Florida, from just over 14,000 total contractors needed in 2010 to approximately 8,500 needed in 2012. These estimates include direct labor and support labor in Florida, both contractor and civil servant, for both FY 2010 and FY 2011 President's budget request (PBR) plans.

The FY 2011 PBR plan extends the Space Shuttle three months, and locates a large amount of work in Florida, including but not limited to the 21st Century Space Complex construction and the program office for the Commercial Crew Program. Additionally, the proposed plan nominates Kennedy Space Center as the deputy program office for the new Flagship Technology Demo program, which will bring some additional workforce demand. The estimates are that workforce demand for the FY 2011 PBR plan will begin and remain higher than the FY 2010 plan, starting at nearly 15,000 needed and falling to approximately 12,000 needed in 2012. This is an increase of as much as 3,500 over the FY 2010 plan, *depending on assumptions of how much design and manufacturing work the commercial crew providers locate in Florida*.

NASA will continue to refine these estimates as program definition matures in preparation for the August 2010 Workforce Transition Strategy report submitted to Congress.

Methodology:

This methodology was used on both the FY 2010 plan and the FY 2011 PBR plan for comparative purposes. To calculate civil service, support, and prime contractor workforce in Florida, we began with dollars for each relevant program. First, the cost of the civil servants is accounted for. Second, it is assumed that the prime contractor will subcontract 33 percent of the procurement dollars. As it is unknown where these subcontractors will be located, this funding is assumed to create no jobs in Florida. The remaining 67 percent is divided, on a per-program basis, to each center.

We then use the American Community Survey to estimate the average salary in Florida for aerospace engineers and technicians. We assume a "wrap" cost—the cost of health care, management, facilities, and profit—of 100 percent of the average salary. For each program, we estimate a percentage of workforce that will be engineers and a percentage that will be technicians. Finally, we divide the previously calculated procurement dollars by the wrapped average salaries to obtain an estimate of the number of jobs for each program, and add up the Kennedy Space Center supplied jobs to determine an estimate for Florida.

Q6. During his speech at the Kennedy Space Center on April 15, 2010, president Obama proposed a $40M initiative to develop a plan for regional economic growth and job creation.

a. Is that $40M from NASA's budget? If so, from where in NASA's budget will the funding come from?

A6a. Yes, the $40M will come from the Constellation Transition budget.

b. What previous NASA programs will be displaced?

A6b. Only the Constellation Transition budget will be reduced.

Q7. Why was 2015 chosen as an appropriate date for making a decision on a new heavy lift launch vehicle? What new technologies are expected to be developed between now and 2015 that will support such a decision?

A7. During his visit to KSC, the President specifically recognized the need for a heavy lift launch capability to carry humans beyond LEO by requiring a decision on a vehicle design no later than 2015. Such a decision would include setting performance goals, identifying lift capability and selecting the general vehicle design—work that will ultimately lay the path for launching a spacecraft for crewed missions into deep space. The 2015 milestone was chosen to make sure that critical technologies for realizing affordable propulsion systems were well underway prior to committing to launch vehicle architecture.

The FY 2011 budget request includes funds for NASA to conduct the important R&D and analysis necessary to make an informed decision on a heavy-lift vehicle no later than 2015. This effort will primarily focus on the development of a U.S. first-stage hydrocarbon engine for potential use in future heavy lift (and other) launch systems, as well as basic research in areas such as new propellants, advanced propulsion materials manufacturing techniques, combustion processes, propellant storage and control, and engine health monitoring. Additionally, NASA will initiate development and testing of in-space engines. Areas of focus could include a liquid oxygen/methane engine and low-cost liquid oxygen/liquid hydrogen engines. This work will build on NASA's recent R&D experience in this area, and the test articles will be viewed as a potential prototype for a subsequent operational engine that would be re-startable and capable of high acceleration and reliability. These technologies will increase our heavy-lift and other space propulsion capabilities and significantly lower operations costs—with the clear goal of taking us farther and faster into space consistent with safety and mission success criteria. In support of this initiative, NASA will explore cooperative efforts with the Department of Defense and also develop a competitive process for allocating a small portion of these funds to universities and other non-governmental organizations. This research effort along with many of our new technology initiatives will be coordinated with the broader Agency technology initiative led by NASA's new Chief Technologist.

More specifically, the FY 2011 budget request challenges us to develop the necessary capabilities to send Americans to places that humans have not explored before, including longer stays at exciting new locations on the Moon, near-Earth objects, strategic deep space zones called Lagrange points, and the planet Mars and

its Moons. We have not sent people beyond LEO in 38 years, and this budget gives us the great opportunity to focus on scouting and learning more about destinations to further explore our solar system and to develop the game-changing technologies that will take us there. It is important that we pursue these objectives to continue leading the world in human space exploration.

While we cannot provide a date with certainty for the first human visit to Mars, we can identify essential capabilities needed for such a mission. These are outlined in the programs within this budget request. They are capabilities that have been recommended consistently for at least 24 years in national level reports of committees and commissions addressing future human space exploration. For example, NASA will begin development of high power electric propulsion and nuclear thermal propulsion systems to reduce mass launched to low Earth orbit; in-space propellant storage and transfer systems to enable refueling of interplanetary transfer vehicles; closed-loop life support systems to reduce consumables such as water and oxygen on long-duration missions; advanced habitat systems incorporating inflatable structures and radiation shielding to increase crew living space and improve safety; aerocapture systems to reduce the mass of propellants required for braking into Mars orbit; and advanced telerobotics to allow astronauts in orbit to control robots on the surface of Mars before the crew lands.

On May 3, 2010, NASA issued a Request for Information (RFI) seeking general information regarding potential launch or space transportation architectures (expendable, reusable, or a hybrid system) that could be utilized by multiple customers (e.g., NASA, commercial and other Government agencies). The RFI solicits information regarding propulsion system characteristics; technology challenges related to liquid chemical propulsion systems; as well as innovative methods to manage a heavy-lift development program to include effective and affordable business practices. The RFI is open to the broad space community, including commercial, other Government agencies and academia. Information obtained from the RFI will be used for planning and acquisition-strategy development for current heavy-lift planning activities, funded at a total of $100M in the FY 2010 Consolidated Appropriations Act (P.L. 111–117).

On June 29, 2010, NASA issued a Broad Agency Announcement (BAA) seeking proposals and industry input on heavy-lift system concepts and propulsion technology. NASA is seeking an innovative path for human space exploration that strengthens its capability to extend human and robotic presence throughout the solar system. The information also may help lay the groundwork for humans to safely reach multiple potential destinations, including asteroids, Lagrange points, the moon and Mars. The total funding available under this announcement is approximately $8M; maximum individual contract award is $625,000. The deadline for submitting proposals is July 29, 2010.

Questions submitted by Representative Marcia L. Fudge

Q1. I strongly support the extension of the life of the International Space Station (ISS) and increases in funding for conducting scientific research on the ISS. Effective management and leadership for ISS Research are critical for the effective utilization of the ISS for science. Glenn Research Center has preeminent capabilities for managing and conducting collaborative research and extensive experience in these efforts. What leadership roles and responsibilities and funding are being provided to Glenn for ISS Research?

A1. The President's FY 2011 budget proposes $50M for basic science and technology research on the ISS. Currently, within this account, research projects are funded at Glenn Research Center (GRC), Kennedy Space Center, Marshall Space Flight Center, Johnson Space Center, and Ames Research Center, all of which have preeminent capabilities for managing and conducting collaborative research and extensive experience in these efforts. The specific sub-allocation to GRC in FY 2011 will be determined later this year during the annual budget process. Historically, GRC has received a significant proportion of available funds based on GRC's leadership role on two research facilities already deployed on the ISS—these include: (1) the Combustion Integrated Rack; and, (2) Fluids Integrated Rack. In FY 2010, approximately $17M was allocated to GRC to operate, maintain, and utilize these facilities for scientific research, as well as to conduct crosscutting technology development on packed bed reactors and two-phase flow separation.

Q2. Additional funding in the FY 2011 Budget Request is provided for upgrading ISS capabilities and demonstration of new technologies on the ISS. Power is a critical capability for both the ISS and future NASA science and exploration missions. Glenn Research Center is eminently qualified to lead upgrades of the

ISS power system and demonstrations of exciting new power technologies on the ISS. What roles and responsibilities and funding are being provided to Glenn for these efforts?

A2. On February 1, 2010, a call was issued to all NASA field installations, including GRC, to propose new concepts for using ISS as a test bed for the research, development, test and evaluation (RDT&E) of next-generation technologies. The response from GRC included a variety of technologies in areas such as power generation, propulsion, optical communications, cryogenics, and robotics. These concept proposals are currently in the evaluation process and a determination will be made by the end of this fiscal year regarding which technologies will be funded for research and development in FY 2011.

Upgrades to the International Space Station power systems are not planned at this time. Investments in developing better power systems for future human spaceflight activities and science missions are part of the President's FY 2011 request for the NASA Exploration Systems Mission Directorate and the Office of the Chief Technologist. Over the next five years, ESMD plans to invest $34M in advanced batteries and fuel cells to power spacecraft, robots, and space suits, and $49M to demonstrate technologies for fission power systems that could be used for nuclear electric propulsion or power plants on the surface of Mars. GRC will lead these two projects to develop new power system technologies. Many of these power technologies could have terrestrial applications for electric vehicles and the smart electrical grid. The Space Technology program is planning on issuing open solicitations in FY 2011 for potential disruptive technologies that could enable power generation, collection and distribution capabilities, whether on-board a flight vehicle, a habitat, or, on planetary surfaces.

Q3. The FY 2011 Budget Request includes significant funding for a technology development and demonstration program to reduce the cost and expand the capabilities of future exploration activities. Glenn Research Center is exceptionally well qualified to develop and demonstrate critical power, propulsion, communications and in-orbit refueling and storage technologies to achieve these goals. What leadership roles and responsibilities and funding are being provided to Glenn to develop and demonstrate these technologies, particularly in-orbit refueling and storage?

A3. Glenn Research Center (GRC) employs more than 1,600 civil servants: scientists and engineers comprise more than half of the workforce, with technical specialists and other skilled workforce focused on space flight systems development, aeropropulsion, space propulsion, power systems, nuclear systems, and communications. Center capabilities that will be tapped in the President's new program include expertise in space flight systems, power and propulsion, program management, and technology innovation, development, and transfer. In April 2010, the Agency announced planned major program assignments across the Agency's Center for new or extended activities proposed as part of the President's FY 2011 budget request. Establishment of program offices and initiation of effort in support of new and extended activities for this proposed new work is contingent upon Congressional approval of the President's FY 2011 request for these activities. Specific new activities planned for GRC include the following:

- Enabling Technology Development and Demonstration (ETDD) Program Office: This new program will provide a path for bringing key exploration technologies to maturity from the laboratory environment through ground testing, and ultimately to flight testing. Initial demonstration projects are likely to focus on: high-power electric propulsion; autonomous precision landing; in-situ resource utilization (including lunar volatiles characterization); human robotic systems (including operating robots from planetary orbit); and fission surface power systems. As the Program Office, GRC will coordinate and manage these activities across the Nation.
- Space Technology Research Grants Program Office: This program will meet NASA's future science and exploration needs, as well as the needs of other Government agencies and the commercial space sector, through technological innovation. This portfolio focuses on foundational research in advanced space systems and space technology performed primarily through collaborative efforts between academia and NASA Centers, with the option of including small business and industry partners. A significant aspect of this program is the Space Technology Graduate Fellowship Project which will train the next generation of aerospace engineers and scientists by funding NASA-related graduate student research performed on campus during the academic year and research performed at a NASA Center during the summer months, gaining

hands-on experience. Research selection for this project will be based on topics that show significant promise for future application toward NASA missions and strategic goals. As the Program Office, GRC will spearhead the development of this approach as part of NASA's new Space Technology Program.

Q4. The Space Power Facility (SPF) at Glenn Research Center's Plum Brook Station is being modified to conduct large scale environmental testing of spacecraft and launch vehicles. Constellation hardware testing was planned to be the first utilization of the new capabilities of the facility. SPF is a world-class facility with unique capabilities. In light of the proposed cancellation of Constellation what are the plans and schedule for utilization of this invaluable asset for exploration and other NASA programs?

A4. The Space Power Facility at GRC's Plum Brook Station in Ohio is now known as the Space Environmental Test facility. Construction started on the facility in 2007 and is currently about 75 percent complete. The remaining construction is expected to be completed this October. NASA believes this unique facility is an invaluable asset for the Nation and thus, we believe that other Government customers such as the Department of Defense, industry and other partners may have use of this unique facility in the future.

Following the release of the FY 2011 budget request, NASA established six study teams within ESMD to ensure we understand the steps (and the implications of those steps) that would need to be taken for an orderly transition of the Constellation Program and to plan for the implementation of the new Exploration program. One of these teams has initiated a broad survey of current Agency infrastructure and workforce to determine what assets could be used by the new programs and projects outline in the FY 2011 budget request. NASA is still assessing the Agency's future requirements for the Space Environmental Test facility and its capabilities as part of that survey.

Questions submitted by Representative Ben R. Luján

Q1. Administrator Bolden, thank you for testifying here today. I wanted to touch on the education component of the President's FY 11 budget request. The President's budget requests $145.8 million in FY 11 to support NASA's Education program, a reduction of about $38 million from the FY 10 enacted budget. Coming from a largely rural, minority-majority state, I know firsthand that the shortage of Hispanics and Native American students in science, mathematics and engineering fields is a real problem that must be addressed. How does the Administration intend to preserve and expand critical minority education and outreach programs, such as the Minority University Research and Education Program, or the Motivating Undergraduates in Science and Technology Project (MUST)? How can Congress help to ensure that NASA continues to prioritize the education of our most underrepresented communities in STEM fields?

A1. Budget

The President's FY 2011 budget requests $145.8M, reflecting the funding required to execute the Agency's education plan in FY 2011. The FY 2011 budget request of $145.8M for NASA Education is an increase of $19.7M from the FY 2010 request of $126.1M. The nearly $20M increase in the FY 2011 budget request will support the Summer of Innovation project.

This FY 2011 budget request embeds competitive opportunities in NASA Office of Education core operations. In the past three years, Congress has appropriated funds for competitive grants supporting global climate change education, K–12 STEM education, and museum and science center activities. Competitive grants offered by the Office of Education in FY 2011 will include:

- Innovations in Higher Education STEM Education, which will offer competitive awards that improve higher education and workforce development;
- Innovations in K–12 STEM Education, providing seed- grants to schools, districts, and non-profit organizations with innovative approaches to improving science, technology, engineering, and mathematics (STEM) teaching and learning;
- Global Climate Change Education (GCCE), which will more actively engage community colleges and minority serving institutions; and
- NASA Informal Education Opportunities; providing funds to science and museums and planetariums.

Reaching Underserved and Underrepresented Audiences

NASA remains committed to ensuring that its education program participants reflect the diversity of the Nation, in terms of race, ethnicity, gender, and geography. NASA's education activities are inclusive of all, but several are specifically designed to appeal to and attract underserved and underrepresented audiences. NASA funding for the Minority University Research and Education Program (MUREP) remains a priority. In FY 2011, MUREP will continue to support students and faculty at Minority Institutions (MIs), including Historically Black Colleges and Universities (HBCU), Hispanic Serving Institutions (HSI), and Tribal Colleges and Universities (TCU), to strengthen their research capabilities and provide opportunities that attract and prepare increasing numbers of underrepresented and underserved students for NASA-related careers. The specific objectives of MUREP are to:

- Contribute to and promote the development of research and academic infrastructure for MIs in areas of strategic importance to the NASA mission.
- Improve the capabilities of MIs to gain support from sources outside of MUREP.
- Increase the participation of underrepresented and underserved students in NASA research and education opportunities.
- Increase the number of underrepresented and underserved students in STEM disciplines and careers by providing scholarships, fellowships and internship opportunities.

MUREP projects such as the Motivating Undergraduates in Science and Technology (MUST) will continue to provide competitive scholarship and internship opportunities for undergraduate students specifically targeting rising sophomores and juniors from underrepresented and underserved groups in STEM disciplines. MUST is administered in collaboration with the Hispanic College Fund, Inc. The most recent MUST cohort of 100 students included 53% Hispanics, 26% African Americans and 4% Native Americans. Students perform well academically (overall grade point average for this cohort was 3.74 on a 4.0 scale), and former MUST participants have been very successful in achieving employment with NASA. In NASA's "Early Career Hiring Initiative," MUST scholars successfully competed for 38 of 173 available positions.

The Curriculum Improvement Partnership Award for the Integration of Research into the Undergraduate Curriculum (CIPAIR) project represents NASA's largest outreach effort to community colleges. Two-year colleges must be the lead or partner on each CIPAIR award. CIPAIR helps two-year and four-year MIs strengthen their STEM curricula in order to attract more students into STEM-based academic programs, retain them, and prepare them for advanced academic or career success. A current CIPAIR partnership is between the University of Texas at San Antonio and San Antonio College, both HSIs. They are partnering to infuse and enrich their engineering and earth sciences curricula with NASA-related technology and research, so that predominantly Hispanic students from both institutions are able to participate in NASA research and education experiences. The relationship is also improving the engineering "2+2 pipeline" for students beginning study at community college and graduating from the four-year university.

A new project in MUREP, Innovation in Global Climate Change Education (GCCE), is based on the previously offered competitive grants opportunity. This project will improve research and undergraduate-level education in the area of global climate change. Competitive grants to MIs will foster collaborations between NASA and awardees, and ensure that work of the grantee is well integrated with other relevant Earth System science education and research efforts within the NASA Science Mission Directorate. GCCE objectives are to:

- Improve the teaching and learning about global climate change through collaborations with MIs.
- Increase the number of undergraduate students at MIs using NASA Earth observation data/NASA Earth system models to investigate and analyze global climate change issues.
- Increase the number of undergraduate underrepresented and underserved students prepared for employment and/or to enter graduate school in technical fields relevant to global climate change.

Space Grant is similarly increasing its work with minority serving higher education institutions and community colleges. For example, the Wisconsin Space Grant Consortium is currently partnering with the College of Menominee Nation to offer the "First Nations Tribal College Sounding Rocket Competition." The first stage of the competition will include evaluation of students' oral reports (April 30, 2010). The

second stage will be the actual rocket competition, the first-ever national rocket competition for tribal colleges. Thirty-one students and faculty advisors are scheduled participate in the event, to be held in Kansasville, WI on May 1, 2010. The third stage of competition will consist of final reports given after all payload data is analyzed. To increase engagement of Native American students at majority institutions, a separate competition division is being considered for future years.

Space Grant is also leveraging its national reach and academic infrastructures to support NASA's K–12 education program. Four Space Grant consortia were recently announced as recipients of awards for the 2010 Summer of Innovation pilot targeting middle school learners: New Mexico, Wyoming, Idaho, and Massachusetts. Two of the awards are of special interest with respect to reaching Hispanic and Native American students and educators. The New Mexico Space Grant Consortium will implement a "Launch and Learn," project for middle school teachers and students. In this project, participants will design and build experiments that study science and engineering problems in suborbital space. Activities will include launching the experiments on a sounding rocket. A strong element of the proposal was the inclusion of New Mexico's underserved and underrepresented populace. The Idaho Space Grant Consortium award funds "NASA Education and STEM Program for Underrepresented Populations." This activity will build physics knowledge and skills in contexts with Native American cultural relevance and sensitivities. Middle school students in Idaho, Montana and Utah will study topics related to NASA's planetary science, robotics, space exploration and aeronautics missions. Students will be drawn from schools on tribal reservations in Idaho, Montana and Utah, and three additional locations in southern Idaho.

Questions submitted by Representative Rob Bishop

Q1. A Department of Defense report, completed by the Industrial Policy office of the Undersecretary of Defense for Acquisition, Technology and Logistics, dated June 2009, entitled "Solid Rocket Motor Capabilities Report to Congress" at page 47, states that a "delay" in the NASA Ares I rocket program "could have significant negative impact[s] on the large SRM prime contractor industrial base and on some of the SRM subtier base, specifically material suppliers." Did you, or anyone in top NASA management, specifically consult with the Department of Defense on the industrial base impacts of a Constellation cancellation decision on the shared defense solid rocket motor industrial base prior to making your recommendation to the President? If so, please provide details as to who at NASA was involved in those consultations, and describe the nature and extent of those consultations, and which Department of Defense officials were consulted.

A1. Per Section 306 of OMB Circular A–11, "Communications with Congress and the Public and Clearance Requirements," NASA cannot relay budget formulation discussions within the Administration. However, NASA would like to emphasize that our Nation's space partners communicate frequently with regard to the Federal Government space enterprise. NASA will continue to work closely with our other Government partners, including the Department of Defense as planning for FY 2011 implementation moves forward. For example, discussions are under way at all levels about ensuring we carefully consider and maintain the space industrial base, particularly with regard to NASA's discontinued use of solid rocket fuel and motors following the cancellation of Constellation. Several recent studies in this area, coupled with current dialogue in the Government's Solid Rocket Motor Industrial Base Interagency Task Force and several other joint forums, also address the this important area and NASA will continue to work to resolve any integrated issues in these joint forums at all levels.

Additionally, NASA Administrator Bolden has consulted with his colleagues at the Department of Defense and the National Reconnaissance Office. In particular, the Administrator has had several meetings with Secretary Donley, General Kehler, and General Carlson, and he plans to continue to meet with them, as program decisions are made and we gain additional insight into the potential relevance to the space industrial base.

Q2. Now that NASA is presumably more aware of the shared industrial base concern with the Department of Defense, are you presently engaged in, or do you plan to have, specific consultations with the Department of Defense and/or the United States Air Force on how to preserve the critical Solid Rocket Motor shared industrial base?

A2. As noted in the response to Question 1, NASA will continue to work closely with our other Government partners, including the Department of Defense, as plan-

ning for FY 2011 implementation moves forward. For example, NASA is working with Defense officials to develop a plan to maintain the intellectual and engineering capacity, including key workforce skills, to support next-generation rocket motors as needed. The task force is co-chaired by the Office of the Secretary of Defense's Acquisition, Technology, and Logistics office and NASA and includes representatives from the Department of Defense, NASA, the Missile Defense Agency, the Air Force, the Army, and the Navy.

NASA has not conducted any formal assessments in these areas. However, NASA worked with Defense officials to develop a plan to maintain the intellectual and engineering capacity, including key workforce skills, to support next-generation rocket motors as needed. The task force is co-chaired by the Office of the Secretary of Defense's Acquisition, Technology, and Logistics office and NASA and includes representatives from the Department of Defense, NASA, the Missile Defense Agency, the Air Force, the Army, and the Navy. This DOD report, entitled "SRM Industrial Base Interim Sustainment Plan" was released to Congress this month.

Q3. Is preservation of the shared solid rocket motor industrial base a concern for NASA management, and if so, please provide your preferred recommendations on how to best sustain this critical shared industrial base.

A3. The health of the shared solid rocket motor industrial base is a concern for NASA management because this industrial base is critical ensuring that the Agency can safely complete the remaining Shuttle flights. However, at this time, the Agency is unclear about its future needs for solid rockets given that the FY 2011 budget request is focused on developing transformative heavy-lift technologies, including new propellants. However, concept heavy-lift vehicles could include solid rocket motors as well as liquid strap-ons and all concepts will be evaluated during a rigorous systems analysis effort to identify the best configuration to meet the Nation's needs.

Questions submitted by Representative Gary C. Peters

Q1. Mr. Bolden, I understand NASA awarded a $1.75 million grant to Dr. Jack Bergman for a space radiation study involving the use of live squirrel monkeys. NASA has justified this research by stating that "there is no information regarding the effects of space radiation on CNS function in non-human primates." But haven't there been previous studies conducted by NASA and the U.S. Air Force examining the cognitive and behavioral effects of space radiation exposure on non-human primates? Why is this study necessary?

A1. There is no information regarding the effects of space radiation on central nervous system (CNS) functioning in non-human primates that NASA can use to establish space radiation exposure limits to protect crewmembers.

In the 1960s, the U.S. Air Force and NASA collaborated on research with rhesus monkeys studying X-rays and protons of energies representative of solar flares. Exposures were carried out in 1965 and 1966; however the monkeys were followed up for possible health consequences for their remaining lifetimes. The study ended in the early 1990s. The initial research was vital to the Apollo program to understand the immediate health consequences of possible solar flare exposure to the Apollo astronauts. A historically large solar event occurred in August of 1972 during the gap between the Apollo 16 and Apollo 17 missions. It has been reported in the scientific literature many times that early radiation sickness and significant increases in cancer fatality would have occurred if one of the Apollo missions had taken place during the August, 1972 solar event. These health consequences were only understood by using the vital data sets previously collected under controlled experimental conditions, by the Air Force and NASA. These same data sets were also used to help make decisions on the shielding requirements for the Orion capsule. However, the 1960s rhesus monkey studies with protons do not provide any information on galactic cosmic ray (heavy ion) effects, and the distinctive types of biological damage they cause that are now recognized as the largest risks for any long-duration space exploration missions beyond low Earth orbit, such as trips to Mars. In addition, while the earlier studies provided information on cancer risks from radiation exposure involving solar protons (from solar particle events), which was appropriate for short-duration Apollo missions, the new research focuses on the astronaut CNS and the effects of galactic cosmic rays (heavy ions) on it and subsequent performance.

With regard to the question about why NASA's proposed research is important, the Agency's proposed study regarding squirrel monkeys will study the long-term effects of space radiation in non-human primates. The study was selected for funding using a rigorous, independent peer review process, is considered necessary to understand the effects radiation will have on crewmembers who will participate in long-

duration spaceflight beyond low-Earth orbit. However, to clarify, while NASA has selected the study for award, NASA has not made the final award.

Given the priority placed on astronaut health, this NASA research study will focus on one of the largest unknowns facing human exploration: the effect of space radiation on an astronaut's CNS. Only in very limited cases can previous NASA research involving mice and rats be extrapolated to humans, and there is no information regarding the effects of space radiation on CNS function in non-human primates. This research is necessary for NASA to develop radiation exposure limits and, if necessary, mitigation strategies for missions within the solar system and for long-duration stays in LEO. The study will help NASA protect crewmembers by setting radiation exposure standards, determining acceptable time limits that astronauts can be in space, and enabling spacecraft designers to incorporate effective shielding technologies.

NASA, and the scientific community it supports, has long recognized its responsibility to treat laboratory animals humanely and to house and care for them properly. NASA well recognizes that only significant and necessary research should be performed on animals and such studies should be minimized. The Agency carefully follows all Federal Government laws and policies regarding the care and use of animals in research, including reviews by appropriate institutional animal care and use committees.

Furthermore, NASA has also developed and continuously implements its own additional rules and processes to further ensure the humane treatment of any animal involved in NASA-sponsored research, both in NASA ground-based laboratories and in manned and unmanned space flights. Specifically, NASA adheres to the animal welfare principles articulated in the "NASA Principles for the Ethical Care and Use of Animals." These principles, which are modeled after those created for the use of humans in research, were created in 1996 by a panel of bioethicists and animal welfare experts, as well as representatives from the American Society for the Prevention of Cruelty to Animals and the Humane Society of the United States. In the case of this proposed study, review by biomedical ethicists and technical experts concluded that the study follows the NASA guidelines.

Appendix 2:

Additional Material for the Record

ADDITIONAL RESPONSES FROM CHARLES F. BOLDEN, JR., ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Material requested for the record on page 20, line 409, by Chairman Gordon resulting from the February 25, 2010, hearing.

With respect to commercial cargo providers, NASA is unaware of any recent company statements that indicated they could get to LEO for less funding than expected. Currently NASA is investing $278M with SpaceX and $170M with Orbital Sciences for each company to develop and demonstrate ISS cargo transportation systems. Both companies continue to make progress with their demonstration programs.

Recognizing the vital importance of the timely completion of the Commercial Orbital Transportation Services (COTS) development program and flight demonstration to meet the cargo resupply needs of the ISS, NASA's FY 2011 budget request includes $312 million in FY 2011 for incentivizing NASA's current commercial cargo program. These funds—by adding or accelerating the achievement of already-planned milestones, and adding capabilities or tests—aim to expedite the pace of development of cargo flights to the ISS and to improve program robustness.

Industry analysts believe that the commercial crew providers may be able to demonstrate their capabilities earlier than a Government-developed system, just as they are expected to develop commercial cargo services earlier than the Government as part of the COTS program. At a hearing before SCST (Science & Space Subcommittee of the Senate Commerce, Science, and Transportation Committee) on March 18, 2010, SpaceX president Gwynne Shotwell testified that her company would have crewed flights via its Falcon 9 and Dragon spaceflight system to the International Space Station within three years of award of a development agreement by NASA. During the same hearing, Orbital Sciences Corp Senior Vice President Frank Culbertson testified that commercially-provided crew systems could be demonstrated by 2015, if capital, safety, and other requirements were met. NASA, however, cannot verify those statements given that the Agency has not yet issued a solicitation for commercial crew proposals. Such information would be included in proposals for award and would be reviewed by NASA at that time. Therefore, the FY 2011 budget request builds upon NASA's commercial cargo efforts by providing significant funding for the development of commercial human spaceflight vehicles, freeing NASA to focus on the forward-leaning work we need to accomplish for beyond-LEO missions. Specifically, the budget request includes $6 billion over five years to spur the development of U.S. commercial human spaceflight vehicles.

While it is not possible to say with certainty that commercial crew could be achieved more cost effectively than Government efforts, commercial crew services will provide many significant benefits to NASA and the Nation. For example, this investment funds NASA to contract with industry to provide astronaut and international partner transportation to the ISS as soon as possible, reducing the risk of relying solely on foreign crew transports, and frees up NASA resources to focus on the difficult challenges in technology development, scientific discovery, and exploration. We also believe it will help to make space travel more accessible and more affordable. An enhanced U.S. commercial space industry will create new high-tech jobs, leverage private sector capabilities and energy in this area, and spawn other businesses and commercial opportunities, which will spur growth in our Nation's economy. And, a new generation of Americans will be inspired by these commercial ventures and the opportunities they will provide for additional visits to space. NASA plans to allocate this FY 2011 funding through competitive solicitations that support a range of activities such as human-rating existing launch vehicles and developing new crew spacecraft that can ride on multiple launch vehicles. NASA will ensure that all commercial systems meet stringent human-rating and safety requirements before we allow any NASA crewmember (including NASA contractors and NASA-sponsored international partners) to travel aboard a commercial vehicle on a NASA mission. Safety is, and always will be, NASA's first core value.

Material requested for the record on page 22, line 465, by Chairman Gordon resulting from the February 25, 2010, hearing.

The letters in question were sent to the Constellation contractors requesting estimates of their termination liability costs for the quarters constituting the upcoming calendar year, from April 1, 2010, to January 1, 2011. We do not believe the letters violated the conditions of the FY 2010 Appropriations Act. The Budget does request funding in 2011 that could be used to cover termination liability costs, but the Antideficiency Act prevents NASA from promising or spending those funds before they are appropriated.

Material requested for the record on page 72, line 1703, by Cong. Kosmas resulting from the February 25, 2010, hearing.

The Space Shuttle is an extremely capable but complicated system to operate, with annual fixed costs of $2.7–3.0B per year. NASA and this Administration are committed to safely flying out the current manifest. The President's budget requested an additional $600M to accommodate the manifest should it drift into the first quarter, FY 2011. Hardware required to fly out the current manifest has already been procured and associated production lines are shutting down as the final hardware is delivered. Major production contracts and production-support subcontracts have been terminated or are close to completion which makes the option of flying additional flights beyond the current manifest difficult. The Agency would incur costs in re-starting these contracts, and there would be a gap between the current manifest and new missions reflecting the need to manufacture and/or assemble components for the latter. In addition, it would be difficult to retain the focus necessary from the workforce to fly safely for multiple years with an uncertain future. If Space Shuttle is extended beyond the current manifest with an uncertain end, it will be extremely difficult to retain the personnel necessary to manage the closeout and fly safely. Finally, after ISS assembly and outfitting is complete the unique capabilities of the Space Shuttle are no longer needed, and the accompanying risk of flying a complicated vehicle is not warranted. After 2010, the primary focus would be crew transportation, logistics and scientific resupply. These tasks can be performed with a simpler and less complicated transportation system.

The 21st Century Space Launch Complex Program at KSC is an initiative to focus on upgrades to the Florida launch range, expanding capabilities to support commercial cargo and crew providers, and transforming KSC into a modern facility. NASA's infrastructure at KSC was originally designed to support the Apollo Program, and was later modified for the Space Shuttle. While this infrastructure has served America well, ongoing concerns about its age have led the Administration to develop this $1.9B range upgrade initiative, based on the longstanding need to modernize integration and operations infrastructure. NASA will coordinate closely with the United States Air Force (USAF), the Federal Aviation Administration (FAA), and the space user community in the coming weeks to develop a requirements plan. NASA currently has a team working with the USAF and FAA on the specific details of the initiative, but the primary focus is to make investments in overall launch and processing operations. This will help ensure that KSC and the larger range shared with Cape Canaveral Air Force Station can continue to serve as a robust, flexible launch site for civil, military, and commercial missions for decades to come.

While NASA is reviewing the specific tasks that would be funded by the $429M requested for this initiative in FY 2011, in order to achieve low-cost, routine, and safe access to space, the Agency must invest in capabilities and technologies that address:

- Manufacturing and Processing;
- Launch Operations;
- Interoperability among Spaceports and Ranges: common systems, open architectures;
- Range Tracking and Surveillance Capabilities and Technologies that protect the public, but also provide test and evaluation capabilities that support an engineering environment;
- Common Communications Architectures;
- Flexible System Telemetry that are Internet Compatible;
- Weather Prediction and Decision-Making Models;
- Inspection and System Verification Capabilities and Techniques;
- Transportation, Handling, and Assembly Capabilities; and
- Supply Chain Management.

Not all of these elements will necessarily be addressed in FY 2011, but the Agency is working with its USAF and FAA partners to develop a plan forward with respect to specific tasks and timeframes. NASA will work to ensure that Congress is kept informed as further details are developed.

Kennedy Space Center will also have a new Program Office to manage $5.8 billion over five years, with the Deputy Program Office at Johnson, to foster private-sector transportation services to Earth orbit. In addition KSC will have a new Deputy Program Office to manage the $6 billion (over five years) program to demonstrate next-generation commercial space flight capabilities. Finally, the increased pace of activ-

ity from the new approach will mean more launches from KSC than would have happened under the old plan.

Material requested for the record on page 90, line 2150, by Cong. Bishop resulting from the February 25, 2010, hearing.

Administrator Bolden has been in contact with Mike Donley, Air Force Secretary and DOD Executive Agency for Space; General Bob Kehler, Commander of Air Force Space Command, and General Bruce Carlson (retired), Director of the Nation Reconnaissance Office (NRO). The Administrator's most recent interaction with these officials occurred in May.

While the FY 2011 budget request for NASA transitions away from the Constellation program, it also invests significant funding to develop technologies and infrastructure to enable human exploration both to low-Earth orbit and beyond. As NASA moves forward with decisions regarding specific spaceflight technologies and programs, the Agency will gain additional insight into the potential impacts to the space industrial base. NASA is working in close consultation with DOD and NRO on the management of the National government space enterprise and will continue to do so. For example, discussions with DOD are already underway regarding NASA's FY 2011 investment in range infrastructure and first-stage propulsion.

Material requested for the record on page 92, line 2198, by Cong. Bishop resulting from the February 25, 2010, hearing.

The FY 2011 budget request transitions away from the Constellation Program, and in doing so, provides a total of $2.5B in FY 2011 and FY 2012 for Constellation closeout and transition costs—funding that is expected to cover contract termination and closeout activity associated with facilities, environmental remediation, workforce, and prime and support contracts. It should be noted, however, that at present, the breakdown of costs is not complete. The Agency is using the current budget planning activities to develop the details; and an implementation plan and coordinated communications with NASA responsible offices and current Constellation contractors are required to further refine this estimate, which is consistent with past planning experience and cost estimation for the Space Shuttle Transition and Retirement. NASA's experience with close-out of the Shuttle program will serve as a useful reference for the complexity of the tasks and the potential associated costs. For example, costs for covering closeout of activities associated with facilities, workforce and prime and support contracts are expected to be covered by the requested funds.

Material requested for the record on page 100, line 2402, by Cong. Posey resulting from the February 25, 2010, hearing.

While the closeout of the Space Shuttle Program and planned transitioning away from the Constellation Program will result in the loss of those specific jobs, the new programs and funding increase in the President's FY 2011 request will result in potentially more total aerospace employment. The vast majority of NASA's budget is spent on workforce and once NASA can begin implementation on these new programs, we anticipate many new aerospace jobs to be created to align with the overall increase in dollars in the FY 11 Budget. NASA is fully committed to maintaining the full civil service workforce to help this nation carryout these programs. NASA is prohibited by the FY 2010 appropriations law from reducing its civil service total. Furthermore, those civil servants, including headquarters civil servants, will be required to formulate and manage the new programs in the President's FY 2011 budget request. Civil servants at all NASA Centers, Headquarters included, will be redirected from the Shuttle and Constellation programs to the new FY 2011 programs.

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