PROPOSED CHANGES TO NASA'S EXPLORATION PROGRAM: WHAT'S KNOWN, WHAT'S NOT, AND WHAT ARE THE ISSUES FOR CONGRESS?

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE AND AERONAUTICS

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

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PROPOSED CHANGES TO NASA'S EXPLORATION PROGRAM: WHAT'S KNOWN, WHAT'S NOT, AND WHAT ARE THE ISSUES FOR CONGRESS?

WEDNESDAY, MARCH 24, 2010

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

The Subcommittee met, pursuant to call, at 2:00 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Gabrielle Giffords [Chairwoman of the Subcommittee] presiding.

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

Hearing on

Proposed Changes to NASA's Exploration Program: What's Known, What's Not, and What Are the Issues for Congress?

March 24, 2010
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

WITNESS LIST

Mr. Douglas Cooke
Associate Administrator
Exploration Systems Mission Directorate
National Aeronautics and Space Administration

Mr. A. Thomas Young
Lockheed Martin (Ret.)

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HEARING CHARTER

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

Proposed Changes to NASA's Exploration Program: What's Known, What's Not, and What Are the Issues for Congress?

MARCH 24, 2010
2 P.M.–4 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

I. Purpose

On March 24, 2010 the Subcommittee on Space and Aeronautics will hold a hearing on the administration's proposed changes to the National Aeronautics and Space Administration's (NASA) exploration program. At this hearing, the Subcommittee will examine:

- The key elements of the proposed changes to the exploration program, including: (1) cancellation of the Constellation Program, (2) investment in the development of a new "commercial crew" space transport industry, (3) provision of additional funding to commercial space cargo demonstration [COTS] providers; (4) establishment of a new research and technology program in support of human exploration; and (5) plans to develop and conduct precursor robotic missions.
- The status of the Constellation Program, including the results of the recent program level Preliminary Design Review;
- The workforce, industrial base, and contractual implications of the administration's proposed changes to NASA's exploration program, were they to be implemented; and
- The applicability of work completed by NASA, including activities carried out in the Constellation Program, to exploration options available to the Nation.

II. Scheduled Witness:

Mr. Douglas Cooke
Associate Administrator
Exploration Systems Mission Directorate
National Aeronautics and Space Administration

Mr. A. Thomas Young
Lockheed Martin (Ret.)

III. Overview

While NASA has stated an overall rationale for changing its exploration program and has identified the key elements of its strategy in the FY 2011 budget request, many specifics on the proposed redirection have yet to be established. For example, at this point in time, NASA cannot provide detailed explanations and associated supporting analyses with regards to:

- Where the redirected exploration program will lead the Nation to, in terms of goals, destinations, and timetable;
- What key assumptions were used to formulate the proposed commercial crew strategy, e.g., projected cost and pricing; market scope; industry cost-sharing; when such service will be operational; government fall-back options if providers are unable to meet NASA's safety requirements, schedule needs, or their cost commitments; and net number of jobs that will be created;
- The need for additional commercial cargo incentives to Commercial Orbital Space Transportation (COTS) partners in light of their progress in meeting agreed-to milestones;

- The analytical basis NASA used to justify canceling the Constellation Program, such as an analysis of alternatives, and a comparative assessment of the relative probabilities of each of the alternatives to Constellation being able to assure survivable crew escapes;
- The basis for the priorities and funding levels for proposed exploration technology development projects, precursor robotic missions, and heavy lift propulsion research;
- The impact of canceling Constellation on NASA's workforce, the Nation's industrial base, and on existing contracts and what mitigating actions would be taken; and
- The strategy for international engagement in human spaceflight activities and exploration under the proposed plan.

At this hearing, members will have an opportunity to examine these issues in greater detail. Mr. Douglas Cooke, NASA's Associate Administrator for Exploration Systems Mission Directorate, the organization responsible for managing the Constellation Program and transitioning to the proposed redirection, will be a witness at the hearing. In addition, Mr. A. Thomas Young, who has had extensive experience in both the public and private space sectors, can provide insight into issues raised by the proposed changes to NASA's exploration program that Congress should consider in its deliberations on the president's FY 2011 budget request for NASA.

IV. Background Information

Key Changes to NASA's Human Space Flight Program Proposed in the FY 2011 Budget Request

NASA proposes, in its FY 2011 budget request, to (1) cancel the ongoing Constellation Program; (2) extend operations of the International Space Station (ISS) until 2020 and possibly beyond; (3) cultivate an expanded space exploration industry through a new commercial crew transport program and rely on that industry for access of its astronauts to the ISS; (4) invest in research and technology development and demonstrations including heavy lift and propulsion technology, that will enable human exploration beyond Earth; and (5) conduct precursor robotic missions.

Cancel the Constellation Program

Citing that the Constellation Program was "*trying to recreate the glories of the past with the technologies of the past*", the administration proposes to terminate the program and initiate closeout activities. NASA indicates that the FY 2011 budget request funds:

- Termination and liability for existing contracts (including severance pay);
- Closeout costs of content and property disposition;
- Costs to render safe facilities no longer in use, mothballed, or targeted for demolition;
- Potential environmental remediation of agency direct and support contractor facilities no longer in use; and
- Coverage for transitional civil servants as new programs are being initiated.

$1.9 billion is allocated for these activities in FY 2011; NASA plans to request $600 million in FY 2012. A detailed breakdown of funding has not been provided. Such detail would help Congress better understand the NASA Chief Financial Officer's (CFO) reported characterization of the $2.5 billion in NASA's Fiscal 2011 budget request to terminate the Constellation Program as being probably "oversubscribed." According to the CFO's reported remarks, some termination-related items are not included in the $2.5 billion figure.

Extend ISS Operations until 2020 and Beyond

The administration proposes to extend use of the ISS beyond 2016, likely through 2020 or beyond, in order to utilize the orbiting facility as a basic research facility and a test bed for exploration technology development and demonstrations. NASA is requesting $2.78 billion in its proposed FY 2011 budget to support these efforts and to initiate activities to increase ISS functionality; a total of $15.3 billion is projected for the period of FY 2011 through FY 2015.

No funding was identified in prior NASA budget requests for ISS operations beyond 2015. Funding for future human space flight-related activities in prior projec-

tions assumed that operations would be terminated by the end of 2015 to help defray Constellation Program costs.

Rely on Commercial Cargo Services and Cultivate a Crew Services Industry

When the Space Shuttle is retired, NASA anticipates that crew access to the ISS will be provided by acquiring seats on Russian Soyuz spacecraft until the 2016 timeframe.

Under the president's proposal, the agency plans to cease using Soyuz spacecraft at that time and anticipates using commercially provided crew transport services instead. Under the ISS international agreements, NASA is responsible for providing crew transport for four U.S. and International Partner astronauts to and from the ISS twice a year, as well as providing a crew rescue capability at the ISS for the four astronauts. NASA plans to rely on commercially provided cargo transport services for ISS resupply starting in the 2011 timeframe using its Commercial Resupply Services (CRS) contract. Funding in FY 2011 for ISS cargo/crew services is about $857 million; a total of $5.77 billion is projected for the period of FY 2011 through FY 2015.

The FY 2011 budget request also proposes a significant investment, spread over five years, that NASA says is intended to spur America's space industry. According to NASA, it will build on "*established partnerships with the emerging commercial space sector through the Commercial Orbital Transportation Services (COTS) effort and expand the market to include a range of both cargo and crew vehicles*."

Regarding the existing COTS effort, NASA proposes to allocate $312 million in FY 2011 for "*incentivizing NASA's current commercial cargo program to improve the chance of mission success 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*." According to NASA, the two COTS program's funded partners, SpaceX and Orbital, are progressing toward flight demonstrations that involve docking at the ISS, in early CY 2011 [The COTS Program has two unfunded partners in PlanetSpace and SpaceDev]. The $312 million requested for FY 2011 is in addition to the $500 million NASA had already planned to spend on the COTS demonstration effort and represents a 62% increase in the cost of the COTS program. In addition, NASA has already paid $214.3 million to Orbital and SpaceX under the follow-on CRS contract, with the payments being described by NASA as "*in support of post-demonstration missions*."

According to NASA's budget justification, "*The Commercial Crew Program will provide $6 billion over the next five years to support the development of commercial crew transportation providers to whom NASA could competitively award a crew transportation services contract analogous to the Cargo Resupply Services contract for ISS. These funds will be competed through COTS-like, fixed-price, milestone-based Space Act Agreements that support the development, testing, and demonstration of multiple commercial crew systems*." The budget justification also states that "*As with the COTS cargo program, some amount of private investment capital will be included as part of any Space Act Agreement and NASA will use this funding to support a range of higher- and lower programmatic risk systems. Unlike the COTS program, which exclusively funded entirely new and integrated systems (launch vehicles plus capsules), this program will also be open to a broad range of commercial proposals including, but not limited to: humanrating existing launch vehicles, developing spacecraft for delivering crew to the ISS that can be launched on multiple launch vehicles, or developing new high-reliability rocket systems*."

NASA has provided no information as to whether the $6 billion requested is the government's total share needed to complete the proposed demonstrations or just represents the five-year total in the agency's budget runout. It is also unclear whether NASA plans to award crew transportation service contracts following completion of the demonstrations or whether the agency would plan to award contracts before the companies had ever demonstrated their systems, as was done with the CRS contracts for cargo delivery to the ISS. No estimate of the cost of these follow-on contracts is provided. Finally, no information has been provided as to the percentage of the development and demonstration cost to be borne by the commercial participants [e.g., 50%, 80%, 0%].

Invest in Research and Technology Needed for Human Exploration

The FY 2011 budget request proposes a major shift in emphasis from building human space flight systems to technology development. In describing this change, NASA stated that:

"*We believe that the technology shortfall we face is so fundamental that incremental changes or tinkering on the margins will not be sufficient to address current*

and future needs. Rather, a fundamental 're-baselining' of our Nation's exploration efforts is needed. We must invest in fundamentally new innovations for space technology, and new ways of doing business, if we are to develop a space exploration and development program that is truly sustainable over the long term."

The budget request provides no explanation as to why investing in new technologies cannot be undertaken in addition to—rather than in place of—the planned exploration flight program.

According to NASA, activities aimed at advancing technologies needed to expand human exploration opportunities, reduce mission costs, and contribute NASA innovation to broader national challenges and applications will be funded in and managed by the Exploration Systems Mission Directorate (ESMD). The agency's budget justification indicates that this will be accomplished through investment in the demonstration of flagship technology projects, as well as enabling technology development and demonstration. ESMD's Exploration Technology and Demonstrations activities are proposed to be funded at $652.4 million in FY 2011; a total of $7.82 billion is projected for the period of FY 2011 through FY 2015.

NASA states that it believes that projects selected as in-space, Flagship Demonstrations will be significant in scale, and offer high potential to demonstrate a new capability and reduce the cost of future exploration missions. NASA officials have told the Subcommittee that in FY 2010, the agency plans to develop long-term roadmap and approach for near-term missions. According to NASA, the evaluation of highest leverage demonstrations is underway and a "Mars destination is a driving case for high leverage demonstration and technology." The first three primary technology targets for single or combined missions are proposed to include in-orbit propellant transfer and storage; lightweight/inflatable modules; and automated/autonomous rendezvous and docking. The fourth flight program would include candidates such as aerocapture/entry, descent and landing; advanced life support; and advanced in-space propulsion. In FY 2011, NASA proposes to initiate several Flagship Technology Demonstrators, each with an expected lifecycle cost in the $400 million to $1 billion range, over a lifetime of five years or less, with the first flying no later than 2014.

Smaller scale development and testing of key, long-range exploration technologies are proposed to be pursued as part of the Enabling Technology effort. Projects range from laboratory experiments to Earth-based field tests and in-space demonstrations and will be aimed at transitioning relevant technologies from lower to higher technology readiness levels. In FY 2011, NASA proposes to initiate demonstration projects leading to flagship/precursor missions in the areas of in-situ resource utilization; autonomous precision landing and hazard avoidance, advanced in-space propulsion, and tele-operation of advanced robotic systems. In FY 2012, NASA proposes to conduct other potential long-range technology development projects such as radiation shielding; high-efficiency space power systems; and entry, descent, and landing technology.

According to NASA, ESMD will also lead research and development (R&D) activities related to space launch propulsion technologies. The agency proposes in its budget justification that this propulsion R&D effort 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. NASA says that advanced in-space propulsion technologies may include nuclear thermal propulsion, solar and nuclear electric propulsion, plasma propulsion, and other high-power and high-efficiency propulsion concepts. The proposed FY 2011 funding level for heavy lift and propulsion technology is $559 million; a total of $3.1 billion is projected for the period of FY 2011 through FY 2015. The level of detail justifying this funding level and selected technologies has not been provided by NASA. The budget request eliminates the development of a heavy lift launch vehicle planned as part of the Constellation Program [Ares V].

Conduct Precursor Robotic Missions

Another new initiative included in the FY 2011 budget request relates to the conduct of precursor robotic missions. According to NASA, it will send precursor robotic missions "*to candidate destinations for human exploration such as the Moon, Mars and its moons, Lagrange points, and nearby asteroids to scout targets for future human activities, and identify hazards and resources that will determine the future course of expanding human civilization into space. Projects will make critical observations, test approaches and operations concepts, and identf specific target destinations directly beneficial to future human space activities. Instruments, destinations and missions will be prioritized based on their utility to future human activities.*"

According to information provided to Congress, NASA proposes to initiate at least two mission formulations in FY 2011, (1) lunar mission demonstrating tele-operation capable of transmitting near real-time video to Earth, investigations for validating availability of resources for extraction, and (2) additional candidate missions that may include landing on near-earth asteroids or on the moons of Mars (Phobos and Deimos) and landing in-situ resource utilization capability to process lunar or asteroid materials into fuel and/or other exploration enabling materials.

It is worth noting that NASA's Science Mission Directorate's Advanced Composition Explorer (ACE) Explorer mission, launched in 1997, has been orbiting the Lagrangian L1 libration point since that time. In addition, the Science Mission Directorate has placed the STEREO (Solar TErrestrial RElations Observatory) spacecraft at a Lagrange point and plans to send a spacecraft to a Lagrangian point again in 2014 when the James Webb Space Telescope is launched. Finally, the ability to transmit real-time video from the Moon to Earth is similar to that projected to be demonstrated as part of Google Lunar X Prize activities.

Status of the Constellation Program and Recent Accomplishments

The Constellation Program, which the administration proposes to cancel, 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 the end of February 2010, NASA reported that it had spent a total of about $9.7 billion on Constellation. If the $2.5 billion NASA has requested for proposed transition costs (including close-out of Constellation activities) is accurate, that will mean that approximately $14.5 billion will have been expended on the Constellation Program upon the program's termination, if that occurs. This figure includes the amount appropriated for FY 2010 and that provided for exploration activities by the Recovery Act.

Limitations on the Use of FY 2010 Appropriations

In the Statement of Managers accompanying the FY 2010 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. According to NASA, the Constellation Program is currently proceeding per the enacted FY 2010 appropriation.

According to NASA, all work that is currently under contract for Constellation will continue. The Administrator has instructed the Constellation Program to refrain from initiating new work not currently under contract, and also to refrain from expanding the scope of any work that currently is under contract. As of March 11, 2010, NASA has canceled five planned procurements, including planned studies: the Exploration Ground Launch Services (EGLS) solicitation at the Kennedy Space Center (KSC); the Vehicle Assembly Building High Bay modification solicitation at KSC; the Water Basin construction solicitation at the Langley Research Center; the Altair Conceptual Design Contracts solicitation at the Johnson Space Center; and the Ares V heavy-lift design trades solicitation at the Marshall Space Flight Center.

In terms of activity in FY 2010, NASA ESMD officials told Subcommittee staff during a FY 2011 budget request presentation that the Directorate and the Constellation Program are currently proceeding per the enacted FY 2010 appropriation, specifically:

- The program is working to complete Preliminary Design Review and major tests scheduled for FY 2010 (e.g. Pad Abort 1); and
- The Directorate will continue incremental funding of contracted tasks for existing contracts;

As of January 2010, the Constellation Program has spent close to $1 billion of FY 2010 funding in execution of the Program. This includes a multitude of contracts and other procurement instruments with over 400 companies, universities, and other government entities.

Constellation Program Accomplishments as of November 2009

Staff members from the subcommittee were briefed by NASA officials in November 2009 on the status of the Constellation program. At that time, they were told that:

- NASA's near term plan remained the same, that is, to maintain March 2015 as the goal for the first crewed Orion/Ares flight to the International Space Station, subject to any impact from potential funding changes as a result of Congressional Continuing Resolutions.
- Constellation had been executing the program for about four years and was well into the development phase.
- Technical progress to date, NASA officials said, was substantial:
  - Preliminary Design Reviews (PDR) for the Initial Capability had been concluded for Ares I and Orion and PDR checkpoints were completed for Ground Operations, Mission Operations and Constellation Program; [Subsequent to the November 2009 briefing, NASA informed the Subcommittee that the technical portion of the program's PDR board was completed on March 5, 2010]
  - Ares I had successfully completed its Thrust Oscillation Technical Interchange Meetings in support of the Constellation Program PDR scheduled for March 2010;
  - Initial Capabilities major development contracts were active and underway for both Orion and Ares I;
  - Constellation Space Suit Systems Contract re-award occurred in March 2009 and definitization was expected soon;
  - Ares I–X test flight successfully launched in October 2009;
  - Ares I DM–1 ground test was successfully completed in September 2009; and
  - Orion Attitude Control Motor Development Motor Test was successfully completed in December 2009.

According to NASA's list of planned Constellation Program events dated March 12, 2010, an interim Critical Design Review (CDR) is scheduled for July 2010.

What is Not Known and What Issues Congress May Wish to Consider

While NASA has provided its overall rationale for moving in another direction and has identified the key elements of its strategy in its FY 2011 budget request, the proposed change in the agency's exploration program is not accompanied by specifics. As such, the absence of detail contributes to a number of issues Congress may wish to consider.

Specifics on Exploration Goals and Destinations

- ***What are the projected dates and destinations in the proposed human exploration program?***

  In his prepared statement submitted for the Committee's February 25, 2010 hearing on NASA's FY 2011 budget request, the NASA Administrator said:

  "Since the introduction of the budget, many have asked what the destination is for human space flight 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 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 Administrator provided another perspective while speaking before the Washington Space Business Roundtable, Satellite 2010 Conference on March 16, 2010. At that event, the Administrator said:

"I often hear the criticism that under the President's plan we have no destination. This is also not true. The ultimate destination in our solar system for our exploration efforts is Mars, but we don't have the technological wherewith-all to safely get humans there yet. In order to reach this destination, we need a robust research and development program to help us provide the capabilities that will make this goal attainable."

The proposed strategy would eliminate any specific human space flight program destinations or timetable. Congress had provided direction on destinations and timetable in the past two NASA Authorization Acts, and the content of NASA's budget requests reflected that direction. The NASA Authorization Act of 2005 directed the NASA Administrator to manage human space flight programs to strive to achieve "*Returning Americans to the Moon no later than 2020*", and "*Enabling humans to land on and return from Mars and other destinations on a timetable that is technically and fiscally possible*." NASA's FY 2008 budget request submitted in February 2007 acknowledged that "*The President and Congress committed the Nation to a journey of exploration; returning to the Moon in the next decade, then to Mars and beyond*" and proposed initiating the Constellation Program to implement that commitment. The administration's FY 2010 budget request reiterated the goal of "returning Americans to the Moon by 2020."

In the NASA Authorization Act of 2008, Congress affirmed its support for "the broad goals of the space exploration policy of the United States, including the eventual return to and exploration of the Moon and other destinations in the solar system and the important national imperative of independent access to space" and "activity related to Mars exploration".

Extent of Consultations Prior to the Proposed Redirection

- ***How did the president go about this decision, who did he reach out to, and who was brought in to make the decision?***

  According to the Administrator's response to Subcommittee Chairwoman Gabrielle Giffords at the Committee's February 25, 2010 hearing, he consulted with the president but characterized his discussion as pre-decisional, adding that he was "*not at liberty to share that*." The Administrator did not indicate whether NASA made any specific recommendations, when they may have been made, or whether they were adopted.

- ***Did the NASA Administrator or the president consult with the Department of Defense on the impact to the industrial base before the announcement of the Constellation Program's cancellation?***

  According to the Administrator's response to Rep. Rob Bishop at the Committee's February 25, 2010 hearing, he had informal conversations with senior persons in DOD, and that while not talking specifically about the impact of the cancellation of the Constellation program, the Administrator said he asked for information on impacts on the industrial base, particularly with reference to solid rockets. He agreed to provide the names of DOD officials he spoke to for the record.

  It is worth noting that, according to a recent *Air Force Times* article, the Air Force's Deputy Under Secretary of the Air Force for Space Programs said at a recent Senate hearing that "*the Obama administration had not asked the Air Force to examine the effects of canceling NASA's Constellation program before the Feb. 1 announcement*."

Basis for the Proposed Commercial Crew Strategy

- ***Were market studies of commercial human spaceflight used by NASA and the administration independently conducted?***

  According to his response to Chairman Gordon at the Committee's February 25, 2010 hearing, the NASA Administrator said that NASA had not done any market surveys nor had he been asked to. Consequently, he said that he is "*depending upon surveys and information that has come from the industry themselves*."

  According to a summary of a March 8, 2010 meeting at the National Research Council by *Spacepolicyonline.com*, staff from the Office of Science and Technology Policy said that a 2002 study by the Futron Corporation entitled "*Space Tourism Market Study: Orbital Space Travel & Destinations with Suborbital Space Travel*" was one of the main inputs that gave the administra-

tion confidence in the potential non-governmental market for commercial crew services. The study included the analysis of a survey by Zogby International that sought to identify the market size, potential for growth, and the characteristics of the market's customers. The Futron study forecasted the market demand for orbital and suborbital flight over the 20 year period from the time the study was conducted. The study stated that for orbital space travel, "*Given the current ticket price of US$20 million per person, affordability is the major barrier to becoming a viable customer for orbital space travel*." According to the Futron report, "*at a current ticket price of US$20 million for an orbital trip, the potential customer's minimum net worth would have to be US$200 million*." The Futron study characterized customers meeting such net worth levels as "*super-affluent*."

The Futron study forecasted that from 2002–2009, 23 tourists would fly on the Soyuz. Space Adventures, Ltd., which states on its website that it is the only private space exploration company to have sent paying passengers into space, has sent 7 paying passengers via the Soyuz in the 2002–2009 period—30 percent of Futron's forecasted market for that period. Taking into account the analysis of the Futron/Zogby market survey, the Futron report provided a base forecast that assumed "*the current ticket price of US$20 million at the beginning of the forecast* [in 2002], *linearly decreasing to US$10 million in 2012, and further declining to US$5 million by 2021*" which at a $5 million per seat charge would expand the pool of potential passengers to those with net worth levels of at least $50 million. Assuming that a commercial crew company or companies provide the price reductions predicted in the market study, Futron forecasted that a total of some 500 passengers would fly commercially over the next twenty years. However, at a March 18, 2010 Senate subcommittee hearing, SpaceX's CEO quoted a price of "*less than $50 million a seat*", while Orbital's Senior Vice President estimated that the cost of an individual mission for Orbital's system would be "*probably around three or four hundred million dollars*". In September 2009, an Orbital spokesman indicated their commercial crew system would be capable of carrying three to four astronauts.

NASA's FY 2011 budget justification states that, "*Once established, these* [commercial crew] *services will not only allow astronauts to travel to the International Space Station, they will ultimately open space travel to many more people across the globe*." Considering the analysis conducted by Futron Corp., which was used to inform the administration's plans for human spaceflight, taxpayer funding for the development of commercial crew services—$6 billion for the years FY 2011 through FY 2016 as identified in the FY 2011 budget request—would in essence be supporting a market for orbital space travel forecasted to be limited to a total of about 500 U.S. and non-U.S. individuals over a twenty year period who have net worth levels ranging from a minimum of $50 million to in excess of $200 million. Whether the reallocation of Federal funding from the government's existing Constellation Program to enable such a market is the best use of those taxpayer dollars is a public policy issue for Members to resolve. No information has yet been provided to the Subcommittee to indicate the Administration's rationale for assigning such a priority to enabling that market.

- ***What is the rationale for the decision not to include a government-led crew transport system development program as a "fallback option?"***

  The rationale is not identified in NASA's budget justification. It is worth noting that the Augustine Committee report, in commenting on NASA's need for a fallback option, said that:

  "While there are many potential benefits of commercial services that transport crew to low-Earth orbit, there are simply too many risks at the present time not to have a viable fallback option for risk mitigation."

- ***How was the estimate of $6 billion for development of commercial crew derived? Does this represent the totality of the government's share of development and demonstration costs?***

  The basis for the $6 billion is not included in NASA's budget justification, including detail on whether this represents the totality of the government's share of development and demonstration costs. The Augustine Committee had estimated that the cost to NASA of creating an incentive for industry to develop a commercial transport capability for crew was about $5 billion. However, that cost was based on estimates provided by would-be commercial providers and the assumptions behind the estimates were not provided.

- ***What amount of cost-sharing by potential commercial crew transportation providers did NASA assume in determining its $6 billion partnership contribution?***

  The budget justification states that "*As with the COTS cargo program, some amount of private investment capital will be included as part of any Space Act Agreement and NASA will use this funding to support a range of higher- and lower programmatic risk systems*."

  Documents provided in conjunction with NASA's FY 2011 budget justification do not identify what level of cost-sharing by industry was assumed in deriving the $6 billion figure.

- ***What is the basis for cost savings assumed to be accrued from commercial crew services? Was an independent cost estimate analysis performed?***

  NASA's reference to cost savings is couched in terms of affordability. In his statement of February 1, 2010 introducing NASA's FY 2010 budget, the NASA Administrator said:

  "NASA will accelerate and enhance its support for the commercial spaceflight industry to make travel to low Earth orbit and beyond more accessible and more affordable. Imagine enabling hundreds, even thousands of people to visit or live in low Earth orbit, while NASA firmly focuses its gaze on the cosmic horizon beyond Earth."

  At the Committee's February 25, 2010 hearing, the Administrator said in his prepared statement:

  "*This investment* [5-year investment totaling $6 billion] *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*."

  Documents provided in conjunction with NASA's FY 2011 budget justification neither reference how projected savings were derived, nor whether an independent cost estimate was performed.

- ***What contingencies are in place should a commercial crew provider's business fail and shut down?***

  In response to Subcommittee Ranking Member Pete Olson's question at the February 25, 2010 Committee hearing on what backup NASA would use if commercial crew companies failed to deliver, go bankrupt, or could not perform, the Administrator said:

  "The backup is actually—puts us in a better situation than we would have been with Constellation"

  "As it is right now, I have two companies that are bidding on or competing to handle access to low Earth orbit. I am hopeful that both of them will be 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 designed and built system in a single Ares I."

  It is unclear what companies the Administrator was referring to in his response, since NASA has not yet issued any solicitations for commercial crew transportation demonstrations or services.

  Notably, the Augustine Committee's report said, regarding this issue of contingency: "[T]*he commercial community may fail to deliver a crew capability in mid-program, and the task would revert to NASA. This could be caused by either a technical failure or a business failure—a failure to obtain financing, changes in markets or key suppliers, re-alignment of business priorities, or another non-technical reason. Either type of failure would require NASA intervention, and the possibility that NASA would either have to operate the system, or fall back to an alternative*."

  In addition, there is no information available as to what the cost to the government would be to sustain two or more companies. The Department of Defense's experience with the Evolved Expendable Launch Vehicle (EELV) Program where the services from the two initial companies were merged into a single joint venture [United Launch Alliance or ULA] is illustrative of the challenge of assessing future government funding requirements based on as-

sumed future commercial markets. Last week, the CEO of ULA told a Senate subcommittee:

[T]*he consolidation to form ULA was done in part because the commercial market projected in the late 1990s did not materialize as was originally expected and the remaining market was insufficient to sustain two healthy launch service providers. Therefore, we believe the nation's human access to space should not be dependant* [sic] *on the success of a future adjacent commercial market*.

- ***On what basis does NASA estimate that commercial crew services will be available by 2016?***

  At the February 1, 2010 teleconference where NASA and Office of Science and Technology Policy (OSTP) officials, including NASA's Deputy Administrator, briefed the media on NASA's budget request, the latter said that for planning purposes, NASA expected a commercial crew transport system to be ready to go in 2016.

  Documents provided in conjunction with NASA's FY 2011 budget justification do not indicate how the 2016 date was established. It should be noted that the NASA Administrator said during his February 6, 2010 press conference that he was not in his position long enough to warrant his taking potential commercial crew providers' cost and schedule estimates "*to the bank*" and consequently is asking to talk to them on issues of schedule and cost and whether they can still deliver within the time horizon they presented to the Augustine Committee, and if so, under what assumed conditions.

- ***Who assumes the liability for astronauts or researchers transported on commercial crew vehicles?***

  NASA has not indicated who would assume the liability for astronauts or researchers transported on commercial vehicles.

  The Commercial Space Launch Amendments Act of 2004 put an initial regulatory framework in place for commercial human space flight. The intent of the law was to support the development of this private sector effort while also protecting the safety of the uninvolved public on the ground. The law established an "informed consent" regime for carrying space flight crew and participants (passengers). As part of the "informed consent" regime, FAA regulations require an operator to inform in writing any individual serving as crew that the United States Government has not certified the launch vehicle and any reentry vehicle as safe for carrying flight crew or space flight participants. Similarly, the operator must inform each space flight participant in writing about the risks of the launch and reentry, including the safety record of the launch or reentry vehicle type. NASA has not established whether its astronauts or funded researchers would be flying under the "informed consent" regime.

- ***How will NASA ensure that commercial crew transportation systems meet its safety requirements?***

  The Administrator has stated that he is confident that commercial crew vehicles will be safe. In introducing NASA's FY 2011 budget request, he said:

  "*Commercial launch vehicles have for years carried all U.S. military and commercial—and most NASA—satellites to orbit. Now, as 50 years ago when we upgraded existing rockets for the Gemini program, NASA will set standards and processes to ensure that these commercially built and operated crew vehicles are safe. No one cares about safety more than I. I flew on the space shuttle four times. I lost friends in the two space shuttle tragedies. So I give you my word these vehicles will be safe*."

  Documents provided in conjunction with NASA's FY 2011 budget justification indicate that NASA plans to complete its definition of human rating requirements in FY 2010.

  In establishing the human rating requirements for commercial crew vehicles, NASA needs to consider the following:

  - The Aerospace Safety Advisory Panel (ASAP) has expressed concerns about the safety of potential commercial crew vehicles. In testimony before the Subcommittee on February 3, 2010, VADM Joseph Dyer, the Chairman of ASAP, said in his prepared statement:

    "*For these reasons, the Panel stated, "To abandon Ares I as a baseline vehicle for an alternative without demonstrated capability nor proven superiority is unwise and probably not cost effective. The ability of any current*

COTS design to "close the gap" or even provide an equivalent degree of safety is speculative."

- At the Subcommittee's hearing on human space flight safety in December 2009, Joseph Fragola, a safety specialist and former member of NASA's Exploration Systems Architecture Study, said in his prepared statement regarding the Constellation Program's Ares I launcher:

  "It is my belief that the Ares I vehicle, because of its inherent focus on being as safe as achievable from the very start, has the best chance to be an outstandingly safe crew launcher. There is no way to insure safety, and spaceflight will always be a risky endeavor, but a launcher that is designed to be safe from the start, at least to me, is a good way to begin."

- Recently, in response to the administration's proposal for commercial vehicles to provide astronaut transportation to the ISS, NASA's Astronaut Office in a March 2010 memorandum made several recommendations for "*the transition to a commercial-crew vehicle to the ISS which leverages the experience gained in the operation of the Space Shuttle, the ISS, and in the design of Constellation*." The Chief Astronaut, Peggy Whitson, said in the memorandum:

  "*Memorandum CB–04–044, Astronaut Office Position on Future Launch System Safety, was released in May 2004 by the Astronaut Office after the Columbia disaster, precipitated by a reexamination of all operational aspects of human spaceflight and focusing on launch vehicle safety for any next generation of human rated spacecraft. Although flying in space will always involve significant risk, an order of magnitude improvement during ascent compared to Space Shuttle, is achievable with current technology and represents a minimum safety benchmark for future systems. It is highly recommended that any human-rated launch system include a booster with ascent reliability at least as high as the Space Shuttle's and an abort system which, together with the booster, yield a predicted Loss of Crew (LOC) number of 1/1000. This number assumes a loss of one vehicle per 100 launches and a crew escape system providing a 90% probability of survivable crew escape."*

  "*Some boosters are designed to highly loft their ascent trajectory to optimize the capability of their propulsion system and the amount of mass the booster can deliver to orbit. For expendable vehicles, these trajectories are efficient and transparent to the payload. For a crewed vehicle however, aborting from a lofted trajectory puts the crew at a significant survival risk in some scenarios due to high G loads and heating. These pans of the trajectory, where an abort is nonsurvivable, are called black zones. A commercially crewed vehicle must have full envelope abort/escape capability with no black zones."* [A "black zone" is a time period during launch when the crew would be unable to safely escape or abort in the event of a failure of the launch vehicle.]

- ***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?***

  Documents provided in conjunction with NASA's FY 2011 budget justification do not indicate what recourse the government will have in the absence of an alternative government system if commercial crew vehicles are unable to meet NASA's safety requirements.

- ***In the absence of an alternative government system, how will the pricing of the commercial crew transport services be set and enforced?***

  Documents provided in conjunction with NASA's FY 2011 budget justification do not indicate how such pricing will be set or enforced in the absence of an alternative government system.

- ***How many net jobs is NASA assuming will be created by the proposal to seek commercial crew services to support the ISS coupled with the cancellation of the Constellation Program? What is the basis of those assumptions?***

  At the Committee's February 25, 2010 hearing, the NASA Administrator said in his prepared statement:

  "*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".

"*NASA will cancel the Constellation Program in favor of a bold new approach that invests in the building blocks of a more capable alternative to space exploration. This new investment in NASA and the corresponding reorientation of the human space flight program will create thousands of jobs nationwide, offsetting the job losses that may be associated with the cancellation of Constellation.*"

Documents provided in conjunction with NASA's FY 2011 budget justification do not indicate how or whether NASA independently determined the number of jobs that would be created by an enhanced U.S. commercial space industry or when they would materialize, nor do they provide a calculation of *net* number of jobs created nationwide when the cancellation of the Constellation is taken into account.

- ***Has NASA determined what skills its civil service workforce will need to conduct effective oversight of and validation of human-rating, to ensure safe on-orbit operations, and to enable "smart-buyer" practices of any potential commercial crew service? Has NASA determined how that skill base will be preserved?***

  Documents provided in conjunction with NASA's FY 2011 budget justification do not indicate the extent of oversight NASA will apply on potential commercial crew service providers or how human space flight skills will be maintained in the absence of new NASA flight programs.

Basis for Requesting New Commercial Cargo Incentives

- ***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 in revenue from the follow-on contract?***

  According to the NASA Administrator's response to a similar question Chairman Gordon posed at the Committee's February 25, 2010 NASA budget hearing, the Administrator committed to providing the Committee with an answer for the record.

- ***How will the proposed additional funding*** [the $312 million cited above] ***be used***?

  According to NASA's budget justification, the $312 million will be used for "*incentivizing NASA's current commercial cargo program to improve the chance of mission success 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. Risk reduction activities may include adding milestones to complete the Probabilistic Risk Assessment (PRA) to identify early risks. Accelerating enhanced capabilities may include adding milestones for early development of items such as the high energy engine for Orbital's Taurus II upper stage, and Block 2 engine upgrades SpaceX's Falcon 9; a demonstration flight may be added to validate the upgrades. NASA will continue to evaluate the Cargo Resupply Services (CRS) contract to determine if funds can be used to accelerate hardware fabrication and assembly of the CRS vehicles*."

  NASA has not provided further details on what specific activities will be conducted or what the consequences of not funding such an increase would be. It should be noted that the requested funding represents a 62% increase over the funding NASA and its funded partners had previously agreed to as being sufficient to complete COTS demonstrations. Given the additional complexity of a commercial crew transportation system, the percentage increase in cost for commercial *cargo* transport reinforces the importance of determining a credible cost estimate for commercial *crew* transport development before committing to that approach.

Basis for Cancelling the Constellation Program

- ***What evidence has been provided that shows that the alternative to the Constellation Program is better? Was an Analysis of Alternatives (AoA) performed?***

  The Office of Management and Budget fact sheet accompanying NASA's FY 2011 budget request said:

"NASA's Constellation program—based largely on existing technologies—was based on a vision of returning astronauts back to the Moon by 2020. However, the program was over budget, behind schedule, and lacking in innovation due to a failure to invest in critical new technologies. Using a broad range of criteria an independent review panel determined that even if fully funded, NASA's program to repeat many of the achievements of the Apollo era, 50 years later, was the least attractive approach to space exploration as compared to potential alternatives. Furthermore, NASA's attempts to pursue its moon goals, while inadequate to that task, had drawn funding away from other NASA programs, including robotic space exploration, science, and Earth observations. The President's Budget cancels Constellation and replaces it with a bold new approach that invests in the building blocks of a more capable approach to space exploration."

At his hearing before the Committee on February 24, 2010 regarding the administration's FY 2011 Research and Development budget proposal, the OSTP Director said in his prepared statement:

"The new approach—which adds $6 billion over the next five years for NASA—includes a vigorous technology development and test program that will begin to reverse decades of under-investment in new ideas. By extending the life of the International Space Station, it increases the number of U.S. astronauts who will be working in space over the next decade; by supporting the development of private sector capabilities to lift astronauts into low Earth orbit it will shorten the duration of our reliance solely on Russian launchers for this purpose; and by investing in new, game-changing technologies it gives promise of getting our astronauts to deep space destinations sooner, faster, safer, and cheaper than what could realistically have been achieved under the old approach."

OSTP has provided no information to support this statement, nor have any studies, including an analysis of alternatives, been identified to Congress that demonstrate that the new approach "*gives promise of getting our astronauts to deep space destinations sooner, faster, safer, and cheaper than what could realistically have been achieved under the old approach*."

At the Committee's February 24, 2010 hearing on the Administration's FY 2011 Science Programs, the Director of OSTP told Ranking Member Ralph Hall:

Each component of it [Constellation] *was very seriously over budget. So, we think that what we are proposing is a program that has a better chance of success than Constellation did and delivering what the American people want and expect from their space program, which is innovation, which is the forward leading program with exciting vision, exciting ideas, the possibility of ultimately taking Americans into deep space beyond the earth moon system with better technology, more efficiently, more safely than Constellation would ever have been able to manage. And we're doing it in a budget that we can afford.*

The Director did not provide specific examples of any Constellation elements that were "seriously over budget."

At the Committee's February 25, 2010 hearing on NASA's FY 2011 budget request, Rep. Lincoln Davis asked the NASA Administrator to convince him that the program proposed was "better than what we have with Constellation", to which the Administrator replied:

"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 are making a change like this, but we are working on it."

- ***Did NASA conduct independent cost analyses to determine costs associated with Constellation cancellation, termination of workforce, disposition of property and infrastructure, and environmental clean-up?***

  Documents provided in conjunction with NASA's FY 2011 budget justification do not indicate that NASA conducted such independent cost analyses.

- ***What is the plan for the disposition of facilities constructed to support and develop the Constellation Program?***

  Documents provided in conjunction with NASA's FY 2011 budget justification do not indicate that such a plan has been completed.

Basis for Exploration Technology Development Priorities and Funding Needs

- ***What is the basis for the exploration technology development priorities in the FY 2011 budget request?***

  Documents provided in conjunction with NASA's FY 2011 budget justification do not provide specifics on how priorities for propulsion R&D and exploration technology development were established.

- ***What is the basis of the budget requests for propulsion R&D and exploration technology development programs?***

  Documents provided in conjunction with NASA's FY 2011 budget justification do not provide specifics on how requested funding levels for propulsion R&D and exploration technology development were established.

- ***What is the basis of the precursor robotic missions projected by NASA?***

  Documents provided in conjunction with NASA's FY 2011 budget justification do not provide specifics on why NASA must send precursor robotic missions to specific destinations. It is worth noting that NASA has already sent robotic missions to Lagrangian points, asteroids and Mars and continues to plan such missions as part of its Science programs. Also, the Google Lunar X Prize, which is a private activity, has nearly identical objectives as that proposed for the robotic precursor mission to land a robot on the Moon that can be remotely operated and that can transmit near realtime video.

Impact of Cancelling Constellation on NASA's Workforce

- ***Has NASA determined the impact of cancelling Constellation on NASA's workforce?***

  At the Committee's February 25, 2010 hearing on NASA's FY 2011 budget request, the NASA Administrator said in his prepared statement:

  "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."

  Specifics on workforce impacts are not yet developed and the basis for the NASA Administrator's statement that "*Civil servants who support Constellation should feel secure that NASA has exciting and meaningful work for them to accomplish after Constellation*" is unclear. In his response to a question from Rep. Michael McCaul, the Administrator said:

  "I wish I could give you definitive programs that we are going to have now, but we are 2 weeks, 3 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."

  In addition, NASA has not provided any information on how the redirection will affect the types of skills it will need. This is important because it is likely that skills needed under the original plan which assumed NASA's direct involvement in the design of space launchers and vehicles will not be the same under a scenario where the agency procures crew transportation services.

Impact of Cancelling Constellation on the Nation's Industrial Base

- ***What implications does the proposed cancellation of Constellation have for other Federal agencies, such as the Department of Defense's space industrial base?***

  At a March 10, 2010 hearing by the Senate Armed Services Committee's Subcommittee on Strategic Forces, the Deputy Under Secretary of the Air Force for Space Programs said in his prepared statement that:

"Factors contributing to rising launch costs are the depletion of inventory purchased in prior years, reduced number of annual buys increasing unit costs, and a deteriorating subcontractor business base without commercial customers. These industrial base factors will also be affected by the decision to replace NASA's Constellation program with a new, more technology focused approach to space exploration, which will likely reduce the customer base for solid rocket motors and potentially increase demand for liquid engines and strengthen the liquid fuel rocket industrial base. We have initiated several efforts to examine the severity of these business base issues and identify potential mitigation steps."

This issue was also addressed in a recent *Air Force Times* article:

"The Air Force and National Reconnaissance Office could face major increases in the cost of launching satellites as a result of the Obama administration's decision to cancel NASA's shuttle replacement program, a top Air Force official said.

Gary Payton, deputy undersecretary of the Air Force for space programs, told Members of Congress that the Obama administration had not asked the Air Force to examine the effects of canceling NASA's Constellation program before the Feb. 1 announcement.

The military and intelligence community rely on the same manufacturers as NASA to build the rockets that launch their satellites, but the White House plans to turn to commercially owned rockets to launch astronauts following retirement of the shuttle later this year.

Early information shows the price of rocket propulsion systems for the military and NRO 'might double' as a result, Payton said."

At that same hearing, according to the same *Air Force Times* article, Senator David Vitter asked Mr. Payton if the Air Force was explicitly asked the impact on the service of canceling Constellation before the decision was made:

" 'No sir,' Payton said. Six studies are now underway together with NASA and NRO to examine price questions, workforce issues and reliability concerns, he said."

Impact of Cancelling Constellation on Existing NASA Contracts

- ***What is the basis for the $2.5 billion for transition costs associated with cancelling the Constellation Program?***

  Documents provided in conjunction with NASA's FY 2011 budget justification do not provide specifics on how the $2.5 billion figure for Constellation transition costs was established.

  According to a recent article in *Aerospace Daily & Defense Report*, the comprehensiveness of that figure has recently been called into question. The article reported that NASA's Chief Financial Officer characterized the $2.5 billion in NASA's Fiscal 2011 budget request to terminate the Constellation Program as probably "oversubscribed" and that NASA is developing a plan for managing the requested funds and handling contract termination liability whose costs are not included in the $2.5 billion figure.

International Space Collaboration

- ***What is the U.S. strategy for international engagement in human spaceflight activities and exploration under the proposed plan?***

  According to a February 6, 2010 article in *Space News*, the Administrator indicated plans for expanded international collaboration in space:

  "Flexible Path says we're going to multiple destinations and we're going to go there as we develop the capability to do it, ' Bolden said, adding that Obama instructed him to expand NASA's involvement with international partners to accomplish such missions, including collaborative development of a heavy-lift launcher."

  " 'We're going to put international partners in the critical path, which means they may develop a system that we know how to do, but we don't know how to do it as well as they do,' he said."

  "Bolden said greater reliance on international partnerships would be one of the biggest changes NASA would see under his leadership."

  NASA's FY 2011 budget justification does not provide specifics on NASA's plans for international engagement in human spaceflight activities and explo-

ration other than through potential international involvement in some of the proposed advanced technology development programs. How such potential technology development activities would be affected by International Traffic in Arms Regulations (ITAR) restrictions is also unclear.

Chairwoman GIFFORDS. This hearing will come to order. Before we get started we have had some interest from other members from outside committees that would like to attend, and I would like to remind folks that non-committee members are only recognized for questions after the full subcommittee members get a chance to speak.

So without objection, Ms. Jackson Lee, Mr. Perlmutter, and Mr. Posey will be allowed to participate if they so choose.

Good afternoon, everyone. Thank you for being here. I would like to welcome our witnesses today. Both Mr. Doug Cooke and Mr. A. Thomas Young have long and distinguished careers in aerospace, and we look forward to gleaning from their decades of knowledge on the subject.

Mr. Cooke has very generously agreed to give us answers to the many questions that have been raised concerning the President's budget proposal, but it is important for members to understand that Mr. Cooke is not the architect of the proposal.

I have called this hearing today because we have very serious issues to address; the future of America's human spaceflight program and the Congress and the President needs to get this one right. The clock is ticking. It is now almost two months since the Administration's fiscal year 2011 budget request for NASA was submitted to Congress, and there are still too many unanswered questions surrounding it.

We are here today because the President's budget has been found deficient by this Congress and by the American people. It proposes drastic changes in the future of NASA with tremendous impact to high-skilled jobs and high-tech manufacturing capabilities. It could leave our country with no human exploration program, no human-rated spacecraft, and little ability to inspire the youth of America. The budget proposed does all this with very few details to support this new direction.

This hearing is but the latest in a series that have been held by the full committee on Science and Technology and also the subcommittee. It is our job and the responsibility to ensure that American taxpayer dollars are spent wisely. We must be certain that existing programs are worthwhile and well managed, and we must be fully informed of the impact of cancellations of programs.

Over the past few months we have held many hearings to address safety concerns for human spaceflight, the competition of international space programs, and the impact of NASA's programs on the skilled aerospace workforce and industrial base. We have also heard from the Government Accountability Office and NASA's Inspector General, and just last month NASA's Administrator, General Charlie Bolden, testified on the fiscal year 2011 budget proposal.

Unfortunately, the NASA Administrator was unable to satisfy many of the members of this subcommittee. Today we are going to continue to take a closer look at the elements of the proposed plan and try to get additional information to the extent that that information exists. We are also going to examine the impacts and consequences that would flow from its adoption. Some of those impacts are quite profound and quite troubling.

Today we are going to try to review the status of the current Constellation Program with just passed—we have just passed a significant design milestone, and we will determine whether the intent of Congress expressed in the fiscal year 2010 Appropriations Act is being met. This oversight is the purpose of this subcommittee hearing, and we intend to be thorough.

The fact of the matter is that Congress is being asked to support a budget request that proposes the cancellation of the Constellation Program; cancellation of a successful program that has been underway over the past five years, cancellation of a program that has met significant milestones and would keep the United States of America as a world leader in aerospace. We have been asked to support a budget request that will leave this country without a government system to access low-earth orbit and beyond.

In canceling this program we would write off $14 billion in taxpayer money with no apparent plan to make any significant use of the results of that investment. We would make this country dependent on yet-to-be-developed commercial crew services of unknown costs and safety with no government backup system available. We would be very likely to be forced to rely on other nations to access LEO and for the International Space Station for the foreseeable future. We will be left without a concrete plan, destination, time table for exploration beyond LEO.

Additionally, this cancellation would negatively impact the Nation's defense industrial base and would eliminate the program that would ease the transition from the Space Shuttle workforce and help retain key human spaceflight skills and industrial capabilities needed for our future.

In place of good explanations and solid rationale for such sweeping and frankly puzzling changes, we have been given a combination of unpersuasive arguments, and "we are working on the details" responses.

For instance, the commercial crew proposal is lacking all of the basic information that a would-be investor would demand before committing their funds to such a project. For example, what is the proposed cost to the government to develop these systems, how much, if any, of the development costs will be shared by the companies, how much will it cost NASA to buy these services, what else will NASA have to provide to make and keep these companies' operations viable? When can we credibly expect these services to be operationally available, and will they meet our expectation of what is safe enough? What recourse will NASA have if the companies fail to meet safety standards, costs, schedule, and performance? And finally, is there any significant, non-NASA market for these services? It is a viable one, and is it one that we should use scarce taxpayer dollars to promote?

Congress is being asked right now to invest our money in a commercial crew venture without providing us with reasonable expectations for success, and as part of my efforts to find out whether there was a solid factual or analytical basis in last year's Augustine Committee report for the Administration's plan, I directed a series of basic questions to the Aerospace Corporation, the organization that was asked to support the Augustine Committee in this review.

Aerospace's responses, which I am entering into the record as of today's hearing, make it clear that such a basis is lacking in many important areas. There is not a criticism—this is simply not a criticism of Aerospace. It is a distinguished organization, but it does call into question the depth of analysis that the Administration proposes—proposals received before it was sent here to Capitol Hill.

In today's hearing we will address the outstanding questions in the proposed budget regarding human exploration. We ask for clear, fact-based answers. The American people deserve no less.

And as a final note, I would like to share something that I received in the mail recently. I hold in my hand the picture that was sent to me by a seven-year-old boy. He wrote here his name is Noah, and he is seven, and in it he has one of these incredible spacecraft that he has imagined, and it looks like it is about to land on another celestial body. And on it he writes, "We love space." When Noah is grown and considering a career in the area of space, will or will not NASA be that shining light that inspires the youth of America to actually think about the future and the dreams?

Noah is not alone. This committee has made science and math education a priority for young people, and under the leadership of our Chairman, Bart Gordon, we will be reauthorizing the America COMPETES legislation that aims to boost our stem education and workforce in order to keep our country economically competitive. And in hearing after hearing we are informed that one of the biggest components necessary to get young kids inspired and interested in engineering is inspiration.

I believe, and I believe that members of this subcommittee and full committee believe that NASA has been the greatest source of inspiration for our Nation, this world—and this world has ever seen.

The most troubling aspect of the President's proposal in my view, and I believe in the view of my colleagues, is the lack for a real solid plan for human exploration, and this is the pinnacle of inspiration. We expect more from the Administration and frankly from NASA, an organization filled with some of the most brilliant analytical minds on the planet that have come before us today and are here before us today. We expect more than a vague list of hypothetical destinations. We deserve and demand a comprehensive human exploration program that details where we will go, when we will get there, and how we will get there. Only by first determining the mission can we determine the necessary technologies and the time table for development.

It is my firm belief that America should not sit idly by for another 20 years before embarking on an expedition to Mars. I want to see a plan that includes human exploration beyond LEO by the end of this decade, not the following decade. Nothing in this budget gives any indication that that would occur, and I think that is unacceptable. We have the technology. Let us make it happen.

Thank you very much, and now I yield to our Ranking Member.

[The prepared statement of Chairwoman Giffords follows:]

PREPARED STATEMENT OF CHAIRWOMAN GABRIELLE GIFFORDS

Good afternoon. I want to welcome our witnesses today. Both Mr. Doug Cooke and Mr. A. Thomas Young have long and distinguished careers in aerospace, and we look forward to gleaning from their decades of knowledge on the subject. Mr. Cooke has agreed to give us answers to the many questions that have been raised concerning the President's budget proposal, but it is understood that he is not the architect of this plan.

I have called this hearing today because we have a serious issue to address—the future of America's human space flight program—and we need to get it right.

The clock is ticking. It is now almost two months since the Administration's FY 2011 budget request for NASA was submitted to Congress, and there are still too many unanswered questions surrounding it.

We are here today because the President's budget has been found deficient by this Congress and by the American people. It proposes drastic changes in the future of NASA with tremendous impact on high skill jobs and high tech manufacturing capabilities. It could leave our country with no human exploration program, no human rated spacecraft, and little ability to inspire the youth of America. The budget proposal does all this with few details to support its new direction.

This hearing is but the latest in a series that have been held by the committee on science and technology and this subcommittee. It is our job and responsibility to ensure that American taxpayer dollars are spent wisely. We must be certain that existing programs are worthwhile and well managed, and we must be fully informed of the impacts of the cancelation of programs.

Over the past few months we have held many hearings to address safety concerns for human spaceflight, the competition of international space programs, and the impact of NASA's programs on the skilled aerospace workforce and industrial base. We have also heard from the Government Accountability Office and NASA's Inspector General. And just last month NASA Administrator, General Charlie Bolden testified on the FY 2011 budget request.

Unfortunately, the NASA Administrator was unable to satisfy many of the Members of this Committee. Today we are going to continue to take a closer look at the elements of the proposed plan and try to get additional information—to the extent that such information exists.

We are also going to examine the impacts and consequences that would flow from its adoption—some of those impacts are quite profound and troubling.

Today we're also going to review the status of the current Constellation program, which just passed a significant design milestone, and we will determine whether the intent of Congress expressed in the FY 2010 appropriations act is being met.

This oversight is the purpose of this subcommittee hearing, and we intend to be thorough.

The fact of the matter is that Congress is being asked to support a budget request that proposes cancellation of the Constellation program. Cancellation of a successful program that has been underway for the past five years. Cancellation of a program that has met significant milestones and would keep the United States as the world leader in aerospace. We have been asked to support a budget request that will leave this country without a government system to access low Earth orbit and beyond.

In canceling this program, we would write off $14 billion in taxpayer dollars spent, with no apparent plan to make any significant use of the results of that investment. We would make this country dependent on yet-to-be developed "commercial crew" services of unknown cost and safety, with no government-backup system available; we would very likely be forced to rely on other nations to access low Earth orbit and the International Space Station for the foreseeable future. We would be left without a concrete plan, destination, or timetable for exploration missions beyond LEO. Additionally, this cancellation would negatively impact the nation's defense industrial base and would eliminate the program that would ease the transition for the Space Shuttle workforce and help retain key human space flight skills and industrial capabilities needed for the future.

In place of good explanations and solid rationales for such sweeping and frankly puzzling changes, we have been given a combination of unpersuasive arguments and "we're working on the details" responses.

For instance, the commercial crew proposal is lacking all of the basic information that a would-be investor would demand before committing funds to a project. For example:

- What's the proposed cost to the government to develop these systems?
- How much, if any, of the development cost will be shared by the companies?
- How much will it cost NASA to buy these services?

- What else will NASA have to provide to make—and keep—the companies' operations viable?
- When can we credibly expect these services to be operationally available and will they meet our expectation of what is safe enough?
- What recourse will NASA have if the companies fail to meet safety standards, cost, schedule and performance.
- Finally, is there any significant non-NASA market for these services; is it a viable one; and is it one we should use scarce tax dollars to promote?

Congress is being asked to invest taxpayer dollars in a commercial crew venture without providing us with a reasonable expectation of success.

As part of my efforts to find out whether there was a solid factual or analytical basis in last year's Augustine committee report for the Administration's plan, I directed a series of basic questions to Aerospace Corporation, the organization that was asked to support the Augustine committee in its review.

Aerospace's responses, which I am entering into the record of today's hearing, make it clear that such a basis is lacking in many important areas. That is not a criticism of Aerospace—a distinguished organization—but it does call into question the depth of analysis that the Administration's proposals received before they were sent to Capitol Hill.

In today's hearing, we will address the outstanding questions in the proposed budget regarding human exploration. We ask for clear, fact-based, answers. The American public deserves no less.

As a final note, I would like to share something I received in the mail recently. I hold in my hands a drawing sent to me by a seven year old boy scout named Noah. It depicts a spaceship landing on a heavenly body with the accompanying caption, written in the bold script of a child, "We Love Space." When Noah is grown and considering a career or an area of study, will NASA still be that shining light that inspires the nation? Noah is not alone. This committee has made the science and math education of young people one of its highest priorities. Under the leadership of Chairman Gordon, we will be reauthorizing the America COMPETES legislation that aims to boost our STEM education and workforce in order to keep America economically competitive.

In hearing after hearing we are informed that one of the biggest components necessary to get young people interested in science and engineering is a source of inspiration. I believe that NASA has been the greatest source of inspiration that this nation, this world, has ever seen, and I aim to keep it that way.

The most troubling aspect of the President's proposal in my view, and I believe in the view of many of my colleagues, is the lack of any real plan for human space exploration—the pinnacle of inspiration.

I expect more from the Administration and frankly more from NASA, an organization filled with some of the most brilliant and analytic minds on the planet, than a vague list of hypothetical destinations. We deserve and demand a comprehensive human exploration plan that details where we will go, when we will go, and how we will get there. Only by first determining the mission can we determine the necessary technologies and development timeline.

It is my firm belief that America should not sit idly by for another 20 years before embarking on an expedition to Mars. I want to see a plan that includes human exploration beyond low Earth orbit by the end of this decade. Nothing in this budget gives any indication that this would occur, and I find that unacceptable. We have the technology. Let's make it happen.

Thank you, and I now yield to Ranking Member Olson.

Mr. OLSON. Madam Chairwoman, thank you very much for hosting this hearing today. I would like to thank our witnesses for their appearance today. Both of these men bring years of valuable experience and perspectives. I would like to, especially like to commend Mr. Cooke in particular for his service during what must be to say the least an interesting time in the agency's history, especially for your mission directorate. And as the Chairwoman said, I understand you are not responsible for the budget proposal. I will re-holster my Blackberry. Can't get the Texas kid out of Texas, can't get the Texas out of the boy.

Anyway, Madam Chairwoman, I applaud you for your leadership in organizing this committee's examination of NASA's proposed

changes in its human spaceflight program. There are many questions to be asked and information yet to be provided about such a major redirection.

Frankly, from my perspective, too many people are behaving as if these changes outlined in the budget proposal are a fait accompli. That is far from the truth, and no matter what you feel about the ultimate choice that should be made, there are still too many unknowns, too many issues that must be evaluated before Congress can make an informed decision.

And make no mistake about it, that decision is Congress's to make, and this hearing will go a long way toward contributing to that debate.

The President may or may not provide additional details at his appearance on April 15 down at the Kennedy Space Center, but until then in the absence of mission-specific goals and strategies, perception becomes reality. Perception, the perception is that Constellation is dead, and in that regard rests many of my concerns. Let me share with you a couple of them as examples, what I experience when I go back home to the Johnson Space Center.

On March 11 a memo was sent out by NASA halting solicitation of outside design submissions for a future lunar lander. This procurement activity was not a cancelled contract but a cancellation that conflicts with the spirit of current law. It does lead me to question the agency's desire to go beyond low-earth orbit. It is the kind of judgment call that is demoralizing to the workforce. The message we are sending to the workforce, march on. The message we need to send is march on with Constellation as planned. It is the program of record, and until Congress changes it, that is their program that they should follow.

One other concern I have about the workforce is that I am increasingly hearing from civil servants who feel that debate and dissent when they are talking about upcoming Shuttle flights, ISS, or Constellation, they are being squelched within the agency, and this is not directed at you, Mr. Cooke, but the message of principles, they are important to the agency. We can't take them back. We have got to have them throughout the leadership of NASA, an atmosphere where questions, informed dissent, or well-intentioned alternative approaches are not welcome. If that atmosphere is created where they are not welcomed, that is going to lead to a fractured, distracted, and above all else an unsafe environment.

Any onset of that kind of repressive management culture must be avoided. Each upcoming Shuttle mission and the continuous operation of the ISS are too important to the crews, the agency, and the future of human spaceflight. NASA employees must be confident that they can voice their concerns through their management chain without fear of incrimination. They have four Shuttle flights left to go. They are pros, but they are humans, too.

Madam Chairwoman, with each day I have more questions and more doubts about the reasoning behind the Administration's proposed changes in our Nation's human spaceflight program. Until better evidence is brought forward, I will state now that I am not convinced that the abandoning of Constellation is in our Nation's best interest, and I look forward to working with you to seek out answers to those questions.

I thank you, Madam Chairwoman, and yield back the balance of my time.

[The prepared statement of Mr. Olson follows:]

PREPARED STATEMENT OF REPRESENTATIVE PETE OLSON

Madam Chairwoman, thank you for calling this afternoon's hearing. I'd like to thank our witnesses for their appearance today. Both of these men bring years of valuable experience and perspective. I would especially like to commend Mr. Cooke in particular for his service during what must be, to say the very least, an interesting time at the Agency, especially for his mission directorate.

Madam Chairwoman, I applaud you for your leadership in organizing this Committee's examination of NASA's proposed changes in its human space flight program. There are many questions to be asked—and information yet to be provided—about such a major redirection. Frankly, too many people are behaving as if the changes outlined in the budget proposal are a fait accompli. That is far from the truth and no matter what you feel the ultimate choice should be, there are still too many unknowns and too many trades that must be evaluated before Congress can make an informed decision. This hearing will go a long way toward contributing to that debate.

The President may or may not provide additional details at his appearance on April 15, but until then, in the absence of mission-specific goals and strategies, perception becomes reality. And in that regard rests many of my concerns. Let me share with you a couple of them as examples.

On March 11, a memo was sent out by NASA halting solicitation of outside design submissions for a future lunar lander. This procurement activity was neither a cancelled contract nor a violation of current law, but it does lead me to question the agency's desire to go beyond low earth orbit. It's this kind of judgment call that can demoralize a workforce.

And in regards to workforce, I increasingly am hearing from civil servants who feel that debate and dissent—whether talking about upcoming Shuttle flights, ISS, or Constellation—are being squelched within the agency. This is not directed at Mr. Cooke, but a restatement of principle for all leadership throughout NASA. An atmosphere where questions, informed dissent or well-intentioned alternative approaches are not welcome will lead to a fractured, distracted, and above all else, unsafe environment. Any onset of that kind of repressive management culture must be avoided. Each upcoming shuttle mission and the continuous operation of the ISS are too important to the crews, the agency, and the future of human space flight. NASA employees must be confident that they can voice concerns through their management chain without fear of recrimination.

Madam Chairwoman, with each day I have more questions—and more doubts—about the reasoning behind the Administration's proposed changes in its human space flight program. Until better evidence is brought forward, I will state now that I am not persuaded to abandon Constellation. I look forward to working with you to seek out those answers. I thank you and yield back the balance of my time.

Chairwoman GIFFORDS. Thank you, Mr. Olson. The Chair knows that the Chairman of the full committee has entered the room and want to just see whether or not the Chairman has any comments that he would like to make.

Mr. GORDON. This is an important topic, and I am anxious to listen to the testimony. Thank you for having this hearing.

Chairwoman GIFFORDS. Thank you, Chairman Gordon.

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

At this time I would like to introduce our witnesses. As I mentioned earlier, they have long and distinguished careers. First up we have Mr. Douglas Cooke, who is the Associate Administrator of the Exploration Systems Mission Directorate at NASA. Mr. Cooke has had a long and distinguished career with over 35 years of experience in Space Shuttle, Space Station, and in exploration programs. He has led significant activities in each of these areas and

is widely recognized for his leadership in carrying out the Exploration Initiative and the development of the Constellation Program. He has received numerous awards and commendations and is a true national asset. I look forward to his testimony, and in that regard I would also hope that my colleagues who have concerns about the President's proposed direction will recognize, again, that Mr. Cooke is not the President, nor is he the NASA Administrator or the architect of this. He is a dedicated civil servant who is trying to carry out the direction he has been given to the best of his ability. Welcome. We are glad you are here, Mr. Cooke.

We are also fortunate to have as a witness today Mr. Tom Young, who was the Executive Vice President of the Lockheed Martin Corporation and former President of Martin Marietta, and has a long and distinguished career also in aerospace. He has served as Director of the NASA Goddard Spaceflight Center, Deputy Director of NASA Ames Research Center, and has led numerous reviews and taskforces on issues of national importance in both civil and national security space, including serving as Chair of the NPOESS Independent Review Team, Chair of the Mars Independent Assessment Team, Chair of the International Space Station Management and Cost Team, Chair of the Taskforce on the Acquisition of National Security Space Programs, and Chair of the Independent Panel on the Organization and Management of National Security Space among others.

In short, Mr. Young is someone the Nation has come to depend on for wisdom based on experience and on analysis. We had the benefit of his counsel at last December's subcommittee hearing on workforce and industrial-based issues, and we look forward to his testimony again today. Welcome.

As our witnesses should know you each have five minutes for your spoken testimony. Your written testimony, of course, will be included in the record for this hearing, and when you have completed your spoken testimony, we will begin our first round of questions, and each member will have five minutes for their questions for the panel.

I would like to begin this afternoon with Mr. Cooke.

STATEMENT OF DOUGLAS COOKE, ASSOCIATE ADMINISTRATOR, EXPLORATION SYSTEMS MISSION DIRECTORATE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. COOKE. Thank you. Chairwoman Giffords and members of the subcommittee, thank you for the opportunity to appear today to discuss the President's fiscal year 2011 budget request for NASA's Exploration Systems Mission Directorate.

NASA and I personally are grateful for the support and guidance we have received from this subcommittee over the years and look forward to working with you on the enactment of the fiscal year 2011 budget.

In your invitation you asked me to address three matters; the new exploration elements in the fiscal year 2011 budget request, status of the Constellation Program, and the responsibilities and reporting schedules of Tiger Teams that have been established to identify the needed transition efforts and budget planning for new

programs and requests following the proposed cancellation of NASA's Constellation Program.

My written statement provides more detailed answers to your questions, therefore, in the few moments I have let me provide you with an overview of the fiscal year 2011 budget request for the Exploration Systems Mission Directorate.

In this budget request for fiscal year 2011 the United States will pursue a new approach to human exploration through the development and demonstration of transformative technologies and systems capabilities and also robotic precursors to scout potential destinations. This budget challenges us to develop the necessary capabilities to send Americans to places humans have not been before, including longer stays at exciting places we haven't been on the moon, near-earth objects, strategic deep space zones called Lagrange points, and the moons of Mars and Mars itself.

We have not sent people beyond low-earth orbit in 38 years, and this budget gives us the 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 spaceflight exploration. Within our current horizon the ultimate destination for human exploration is, of course, Mars. 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 that are within this budget request.

They are capabilities that have been recommended consistently for over 24 years, and national-level reports of committees and commissions addressing the future human space exploration. In short, the 2011 budget request for exploration includes funding for three new robust programs that will expand the capabilities of future human space explorers far beyond the capabilities that we have today.

NASA will embark on these initiatives by partnering with the best in industry, academia, and other government agencies, as well as with potentially-expanded set of international partners. All of these types of partnerships have been integral to much of NASA's previous success, and they will be vital to ensuring the success of our exploration program.

Our commercial cargo and commercial crew partners will also be vital to the success of the new exploration program. That is why the 2011 budget request provides significant funding for the development of commercial human spaceflight vehicles. Doing so will free NASA to focus on the new work we need to accomplish for beyond low-earth orbit missions.

Additionally, the 2011 budget request includes a 40 percent increase in the investment in human, in NASA's Human Research Program. This increased funding will allow the agency to significantly increase its research in the highest risk to crew health and performance during long duration exploration missions, especially those beyond low-earth orbit.

Lastly, the budget request cancels the Constellation Program and in doing so includes funding for closeout activities in fiscal year 2011 and 2012.

On a personal note, I have worked for NASA for over 36 years, and during that time I have served directly on several program transitions. These have included the post-Apollo development of the Space Shuttle, initiation of the Space Station Program, the post-*Challenger* return to flight, Space Station redesign, direct support to the Columbia Accident Investigation Board, and the initiation of the current exploration programs. So I speak from experience when I say that change is never easy for those who have devoted so much of their professional and personal time and energy to a program they love.

But I also speak from experience when I say that the NASA team, including our industry partners, will do any job asked of us to implement our guidance with professionalism, diligence, and pride. As Associate Administrator for NASA's Exploration Systems Mission Directorate, I am committed to leading the team through this period to develop the best outcome in our forward path.

I know that cancellation of the Constellation Program will personally affect thousands of NASA and contractor—civil servants and contractors. It is difficult for all of us who have worked countless hours, often under difficult circumstances, to make the Constellation Program successful. That work continues now and as we have and continue to work through program and project milestones and major tests of hardware.

I would like to publicly say that I sincerely appreciate and commend the dedication and sacrifice of the skilled Americans and their families who have diligently worked on the Constellation Program and for their contributions to our Nation's human spaceflight program. Civil servants who support Constellation should feel secure that NASA has meaningful work for them to accomplish after Constellation, and our contractor colleagues should know that NASA is working to offer new opportunities for them to partner with the agency on our proposed exploration portfolio.

As I stated, my experience and many transitions helps me understand that these large changes are never taken lightly and that this experience also brings me to understand how important it is to look to the future and that our incredible NASA and contractor workforce will apply the skills and drive to implement what the policy guidance and enacted budget challenges us to do.

We look forward to developing the technologies to take us beyond low-earth orbit, together with our industry, academic, and international partners. Chairwoman Giffords, NASA looks forward to working with the subcommittee on the fiscal year 2011 budget, and I would be pleased to respond to any questions that your members of the subcommittee may have.

[The prepared statement of Mr. Cooke follows:]

PREPARED STATEMENT OF DOUGLAS COOKE

Chairwoman Giffords and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the President's FY 2011 budget request for NASA's Exploration Systems Mission Directorate (ESMD). NASA is grateful for the support and guidance received from this Subcommittee through the years and we look forward to working with you on enactment of the President's new direction.

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. 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 create the new knowledge and capabilities required for humans to venture beyond low-Earth orbit (LEO) to stay.

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. 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.

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 ESMD 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.

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-low-Earth orbit missions. The FY 2011 budget request also includes a 40 percent increase over last year's investment in the Human Research Program, to help prepare for future human spaceflight exploration beyond LEO. Lastly, the budget request includes funding for the Constellation Program close-out activities spread across FY 2011 and FY 2012.

In your invitation, you asked me to address three matters: the new Exploration elements in the FY 2011 budget request; current status of the Constellation Program; and responsibilities and reporting schedules of "tiger teams" that have been established to support transition efforts following the proposed cancellation of Constellation. The remainder of my testimony provides answers to your questions.

Key Elements of the New Plan

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 LEO:

- **Technology Development and Demonstrations**: This effort will include two 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.

- **Heavy-Lift and Propulsion Research and Development Program**: ESMD will lead research and development activities related to space launch propulsion technologies. This effort would 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 in-space testing of in-space engines. Areas of focus could include a liquid oxygen/methane engine and potentially also 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 would 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.
- **Exploration Precursor Missions**: An additional 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? While there may be some synergies between this program and the Planetary Science theme within NASA's Science Mission Directorate, care will be taken to avoid unnecessary duplication. While Science missions are driven purely by science objectives set by the National Academy of Sciences, the Exploration precursor missions will be driven by the needs of human spaceflight. In many cases, there is a synergy between these goals, and ESMD will leverage this synergy when it exists, as we have done successfully for the LRO/LCROSS missions. 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 turn-around, 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.

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. Additionally, NASA plans to 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 approach.

To more fully engage the public in these transformative efforts, NASA will establish a Participatory Exploration Office that will be charged with encouraging public involvement and interaction in the experience of discovery. Imagine how excited 11-year-old elementary school students would be if they got to actually pilot a rover on the lunar or Martian surface while they were learning about the planets in science class. Or imagine college students helping to design exploration payloads that will travel aboard the next-generation exploration precursor robotic missions. This is the primary goal of participatory exploration—empowering the general public to contribute to the Agency's research, development and discovery activities.

With regard to commercial crew and cargo, the FY 2011 budget request builds upon NASA's successful 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. 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 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, the 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.

Lastly, 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 would 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.

Status of the Constellation Program

NASA recognizes that the cancellation of the Constellation Program will personally affect thousands of NASA civil servants and contractors who have worked countless hours, often under difficult circumstances, to make the Constellation Pro-

gram successful. I appreciate and commend the dedication and sacrifice that these skilled Americans have made 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 offer new opportunities for them to partner with the Agency on our new Exploration portfolio.

Consistent with the provisions of the FY 2010 Consolidated Appropriations Act (P.L. 111–117), NASA is continuing to implement the programs and projects for the architecture of the Constellation Program. NASA completed the Constellation Preliminary Design Review earlier this month, and will complete documentation of the PDR this year. In light of the FY 2011 budget request's proposal regarding the Constellation Program, the Administrator has instructed the Constellation Program to refrain from initiating new work not currently under contract, and also to refrain from expanding the scope of any work that currently is under contract. All work that is currently under contract is continuing. These actions are prudent and necessary steps, and are consistent with the provisions of P.L. 111–117.

Please see the attached charts, which provide a list of major program acquisitions to date; the status of key milestones and program activities planned for the Constellation Program in FY 2010; and a brief overview of the accomplishments of the program to date.

"Tiger Team" Responsibilities and Reporting Schedules

Although NASA is continuing Constellation Program activities in FY 2010, at the same time, NASA must plan for all likely budget outcomes so that the Agency is ready to implement any new direction and implement appropriate transition activities. This is consistent with how the Agency plans to implement any pending budget in any given year. Forward preparation and planning work is always necessary, even though a budget has not become law.

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. The work undertaken by these teams is a necessary part of that planning. This is only an evaluation of plans, and no termination action has been directed or taken. The data assembled by the study teams will equip NASA with vital and substantive information that we will need once the new fiscal year begins and once NASA embarks on its efforts to implement the FY 2011 budget request.

The six study teams and their areas of planning are as follows:

- **Constellation Transition**: The team 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 infrastructure and hardware could be used by the new programs and projects. The transition plan will outline three phases as part of an action plan for initial deliverables: Near-term actions, cancellations of Constellation, and transition of assets/resources to new Exploration focus areas and other NASA programs, where appropriate.
- **Heavy Lift and Propulsion Technology**: The team is formulating plans for a program that will investigate a broad scope of research and development activities to support next-generation space launch propulsion technologies. This includes foundational propulsion research and demonstrations of first stage and in-space engines.
- **Commercial Crew**: The team is formulating plans to expedite and improve robustness of ISS crew and cargo delivery. In addition, the team is developing a plan that supports the development of commercial crew transportation providers to whom NASA could competitively award crew transportation services.
- **Exploration Robotic Precursors**: The team is formulating plans for a series of candidate exploration robotic precursor missions to scout targets for future human activity. Potential destinations include the Moon, Mars and its moons, Lagrange points and nearby asteroids.
- **Flagship Technology Demonstrations**: The team is formulating plans for a series of in-space demonstrations that validate next generation capabilities key to sustainably exploring deep space.

- **Enabling Technology Development and Demonstration**: The team is formulating plans for conducting smaller scale development and testing of key, long-range exploration technologies.

The teams are being led primarily by Headquarters personnel, but include membership from the Centers, other Mission Directorates and other Cross-Agency groups. Members were selected based on their subject matter expertise. Each team has the ability to utilize resources anywhere in the Agency, including tapping experts at all Centers.

With the exception of the Constellation Transition team, the teams are engaged in pre-formulation activities: developing program strategy; identifying needs and goals; exploring alternate implementation strategies; and establishing high level milestones and a budget profile. The focus is at the program level with identification of potential projects or missions. Therefore, the teams will not engage in workforce assignments nor will they define Center participation or management of programs. The teams also will not develop or award new contracts. Decisions related to team activities are made through normal Agency approval processes.

It is expected that teams will complete a majority of their work by the end of the 3rd quarter of FY 2010. As that effort is completed over the next several months, NASA will share our findings with Congress and engage with this Subcommittee on our planned next steps.

After assessing the current Constellation baseline status and developing the action plan for a Constellation transition, and receiving appropriate legislative direction, future implementation and execution of the plan will be transferred to a Constellation Transition and Closeout Project. Existing Agency infrastructure will be utilized to the maximum extent possible to codify decisions and conduct reviews, analysis, and integration of transition activities and plans, such as: the ESMD Program Management Council; the Agency Program Management Council; the Center Management Council; the Constellation Control Board; the Systems Engineering and Integration Control Board; the Budget Rollout Integration Team and the Transition Control Board.

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 Subcommittee on implementation of the FY 2011 budget request.

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

Constellation Program FY 2010 Planned Events

(As of March 4, 2010)

- **NOTE: NASA is continuing to execute the FY 2010 baseline program. However, it is possible that changes could happen due to efforts by the Agency to fit within the constraints imposed by the FY 2010 budget. Please see response to Question 2 for more information.**

Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Programmatic Reviews								
	▲3/3 CxTF PDR Kick off		▲5/13 Ares US FSW PDR2 Board					
	▲3/4-5 Cx PDR Board			▲6/2 u/r GO PDR Board				
		▲4/6-7 GO PDR Kickoff			▲7/9 MO PDR			
		▲4/12 Orion Software PDR Board			▲Jul – Ares I Interim CDR			
Development Events								
● 2/11 Orion Parachute Drop Test @ Yuma Proving Grounds						Sep Ares I FS DM-2 Test ●		
● 2/25-2/26 EVA Prime IBR/EVA CSSSS ATP2								
● 3/2-18 Orion PA-1 LAS Softmate/Phasing Test						Sep CM GTA AIT Complete u/r ●		
● 3/17 Orion ACM DM-2 Test (Elkton, MD)								
● 3/23-24 Orion PA-1 Pre-FTRR @ WMSR						Sep – EVA Suit PDR ●		
● 4/1 Orion PA-1 FTRR @ JSC u/r								
● 4/14 Ares FS Drogue Parachute Drop Test @ Yuma								
● 4/15 Orion STORRM DTO FRR								
● May Orion PA-1 Launch @ White sands u/r								
● 5/11-5/13 GO IBR u/r								

ATP – Authority to Proceed
CDR – Critical Design Review
CLIN – Contract Line Item Number
Cx – Constellation
CxTF – Constellation Training Facility
DDT&E – Design, Development, Test & Evaluation
EGLS – Exploration Ground Launch System
EVA – Extravehicular Activity
FS – First Stage
FSW – Flight Software
GO – Ground Operations
IBR – Integrated Baseline Review
MO – Mission Operations
PDR – Preliminary Design Review
US – Upper Stage

3/23/2010

Constellation Program Major Acquisitions

Project	Description
Orion	Orion Contract Award: 31 Aug 2006
Ares I	J-2X Contract Award (PWR): 16 Jul 2007
	1st Stage Contract Award (ATK): 10 Aug 2007
	Upper Stage Production Contract Award (Boeing): 28 Aug 2007
	Instrument Unit Avionics Production Contract Award: 12 Dec 2007
EVA	Space Suit Systems Contract Award: 26 Feb 2010 (Definitized)
Ground Ops	Mobile Launcher contract Award (Hensel-Phelps): 8 May 2008
	Ground Support Equipment IDIQ Contract Award (Multiple): 6 Jun 2008
Lunar Surface Systems	Concept Development Broad Area Announcement (BAA) Contract Awards (Multiple): 28 Jul 2008
	Concept Development Outbrief: 25-27 Feb 2009

3/23/2010

Achievements of NASA's Constellation Program

The following are some of the Orion Project's key achievements:

- The Orion PDR was conducted during the summer of 2009, and completed in August 2009. The PDR was an extensive review of Orion's detailed subsystems and integrated systems designs to date. The PDR board unanimously recommended proceeding with detailed designs toward Critical Design Review (CDR) in February 2011.
- In 2009, NASA conducted preliminary capsule recovery tests at both the Navy's Carderock facility in Maryland and in the ocean near Kennedy Space Center (KSC) in Florida. Using a mockup of the Orion capsule, these Post-landing Orion Recover Tests involved search and rescue teams simulating stabilization and recovery of the Orion capsule in a variety of sea state conditions. Results were intended to lead to design features for both the spacecraft and recovery equipment, as well as contributing to development of the final recovery procedures.
- Fabrication of the Orion Ground Test Article crew module is progressing at the Michoud Assembly Facility in Louisiana. Completion is estimated for the fall of 2010, followed by completion of the service module and launch abort system ground test article, currently scheduled for 2011. NASA is using a friction stir welding technique on this ground test article, and is hoping to demonstrate the longest continuous friction stir weld ever attempted.
- In May 2010, NASA plans to perform its first developmental test of the Orion Launch Abort System (LAS) at the White Sands Missile Range, New Mexico. Orion's Launch Abort System (LAS) includes three newly designed solid rocket motors: 1) abort motor, 2) jettison motor, and 3) attitude control motor. All of these motors have been successfully demonstrated in static firings on the ground. The next step is the Pad Abort–1 test, which will be the first integrated firing of all three motors in a real flight environment.

The following are some of the Ares I Project's key achievements:

- Having completed its PDR in 2008, the Ares I Project is now working toward its CDR, which is scheduled for September 2011.
- In September 2009, NASA and ATK conducted the first successful test of the Ares I's five-segment development motor in Promontory, Utah. Beyond validating the basic performance characteristics of the stage, the test has enhanced modeling and understanding of key attributes that have historically been very difficult to predict analytically such as erosive burning, thrust oscillations and thrust tail off. The next static test, DM–2, is currently scheduled for September 2010.
- In October 2009, the Ares I–X test flight took place at Kennedy Space Center in Florida. Data from more than 700 on-board sensors showed that the vehicle was effectively controlled and stable in flight. Thrust oscillation frequencies and magnitude data from the Ares I–X flight also were consistent with measurements from recent Shuttle flights that were instrumented, leading us to conclude that the oscillation vibration on the Ares I would be within the bounds that the Ares I is currently being designed to. In the end, this test flight provided tremendous insight into the aerodynamic, acoustic, structural, vibration, and thermal forces that Ares I would be expected to experience.
- J–2X Test Hardware Status: Having passed its CDR in 2008, development and verification testing at the component and subsystem level continues. Current planning includes a fully assembled engine, minus the full nozzle extension, to be available the end of calendar year 2010, followed by receipt of an additional developmental engine in 2011. Static fire testing for engines is currently slated to begin in the February-March 2011 time frame.

The following are some of the recent infrastructure achievements for the Constellation Program:

- The Operations and Checkout building at KSC was completed in January 2009, marking activation of High Bay Facility. When outfitted, the O&C will support final assembly of the Orion spacecraft.
- The final 600-foot Lightning Protection Tower at KSC's Pad B was completed in February 2009. This was where the Ares I–X test flight launched from in October 2009.

- Workers at KSC topped out the tenth and final segment of the new mobile launcher (ML) after it was lifted by crane and lowered onto the ninth segment in January 2010. When completed, the tower will be 345 feet tall and have multiple platforms for personnel access. Its base was made lighter than Space Shuttle mobile launcher platforms so the crawler-transporter can pick up the heavier load of the tower and a taller rocket.
- A–3 Test Stand at Stennis Space Center in Mississippi: Construction of the long-duration altitude test stand for the J–2X engine is nearly 75 percent complete. When completed in 2012, the A–3 facility will provide a unique critical capability to simulate environments at greater than 100,000 ft altitude necessary to demonstrate altitude starting and perform full-duration hot-fire testing.
- Space Environmental Test Facility (SET) at Glenn Research Center's Plum Brook Station in Ohio: Construction started in 2007 and is about 75 percent complete. SET is planned for conducting qualification testing of the fully integrated Orion spacecraft, including vibration, acoustics, and EMI testing.

BIOGRAPHY FOR DOUGLAS COOKE

Doug Cooke is Associate Administrator for the Office of Exploration Systems Mission Directorate. The Exploration Systems Mission Directorate is responsible for managing the development of flight hardware systems for future support of the International Space Station and the exploration of the moon, Mars and beyond. This includes development of lunar robotic precursors, critical technologies and human research to support future human spacecraft and exploration missions.

Mr. Cooke has over 35 years of unique experience in the Space Shuttle, Space Station, and Exploration Programs. He has been assigned significant responsibilities during critical periods of each of these, including top management positions in all three programs.

Mr. Cooke's first major challenge began in 1975 when he was tasked with defining and implementing an entry aerodynamic flight test program for the Space Shuttle. This program was successfully implemented during the Approach and Landing Tests in 1977, and early orbital flights of the Space Shuttle beginning in 1981 through 1984.

Mr. Cooke was asked to lead the Analysis Office when the Space Station Program Office was first organized in 1984. He accepted the challenge and led the work that defined the Space Station configuration and many of its design details and technical attributes.

Following the Space Shuttle Challenger accident, Mr. Cooke was assigned to the Space Shuttle Program Office. He helped lead a Civil Service and contractor team to provide the system engineering and integration function that resulted in the return of the Space Shuttle to flight on September 29, 1988. He reached the position of Deputy Manager of the NSTS Engineering Integration Office.

Mr. Cooke has played a pivotal role in planning for future space exploration beginning in 1989. He helped to lead a NASA team that produced the "90 Day Study" on lunar and Mars exploration. Mr. Cooke was subsequently assigned to the Synthesis Group led by Lt. General Tom Stafford, Gemini and Apollo Astronaut. The team produced a report for the White House entitled "America at the Threshold: America's Space Exploration Initiative." Mr. Cooke was selected to be the Manager of the Exploration Programs Office under then Exploration Associate Administrator Michael Griffin, where he initiated and led NASA agency-wide studies for the human return to the Moon, and exploration of Mars.

In March of 1993, the agency undertook the redesign of Space Station Freedom. Mr. Cooke was assigned the responsibility of leading the engineering and technical aspects of the redesign. He was subsequently chosen to serve in the Space Station Program Office as Vehicle Manager, leading and managing the hardware development and systems engineering and integration for the International Space Station. From April to December of 1996, Mr. Cooke served as Deputy Manager of the Space Station Program.

Prior to his current appointment to NASA Headquarters, Mr. Cooke served as manager for the Advanced Development Office at the Johnson Space Center, Houston. Mr. Cooke provided leadership for the planning of human missions beyond Earth orbit; including the Moon, Mars, libration points, and asteroids. This team developed integrated human and robotic mission objectives, defined investment strategies for exploration technologies, and managed NASA exploration mission architecture analyses. Mr. Cooke was detailed to NASA headquarters during portions of this period to contribute to headquarters level strategies for human exploration.

Mr. Cooke served as NASA technical advisor to the Columbia Accident Investigation Board from the time of the accident to the publishing of the report.

Prior to his current assignment Mr. Cooke served as Deputy Associate Administrator for the Exploration Systems Mission Directorate. He has made significant contributions to the structuring of its programs, defining the program content, and providing technical leadership. He initiated and led the development of the Global Exploration Strategy activity that led to defined themes and objectives for lunar exploration. International, science, industry, and entrepreneurial communities were engaged, and they contributed to the development and shaping of these themes and objectives. He has led and guided the development of the planned lunar exploration mission approach and architecture. Mr. Cooke has also led the efforts to define long term NASA field center assignments for lunar hardware development and operational responsibilities. He has been the Source Selection Authority for the major exploration contract competitions. In this role he has successfully selected the companies who will develop the next human spaceflight vehicle, composed of the Orion spacecraft and Ares I rocket.

Mr. Cooke is a graduate of Texas A&M University with a Bachelor of Science degree in Aerospace Engineering.

Major Awards: SES Presidential Distinguished Rank Award—2006, SES Presidential Meritorious Rank Award—1998, NASA Exceptional Achievement Medal—2003, NASA Exceptional Achievement Medal—2002, NASA Outstanding Leadership Medal—1997, NASA Exceptional Achievement Medal—1993, NASA Exceptional Service Medal—1988, JSC Certificate of Commendation—1986, JSC Certificate of Commendation—1983

Chairwoman GIFFORDS. Thank you, Mr. Cooke. Thank you for your service and for your testimony.

Mr. Young.

STATEMENT OF A. THOMAS YOUNG, LOCKHEED MARTIN (RET.)

Mr. YOUNG. Chairwoman Giffords, Mr. Olson, and committee members, I am pleased to have the opportunity to present my views on the United States Human Spaceflight Program.

The proposed NASA fiscal year 2011 budget represents a significant departure from the current program and raises some important issues worthy of debate prior to setting a course that will define human spaceflight for many decades.

Continuation of the International Space Station and Mars as the ultimate human exploration destination appear to be the consensus. While Mars is not explicitly identified, subsequent Administration statements suggest this conclusion. Areas with significant differences in implementation approach are, one, the method of transporting humans to earth orbit and specifically to the International Space Station; two, the need for a detailed plan for human exploration beyond earth orbit; three, the development of a heavy lift capability to submit—support missions beyond earth orbit; four, the development of a capsule to support astronauts traveling to and beyond earth orbit; and five, the definition of a technology program focused on specific mission needs.

Approaches being discussed to provide transportation to earth orbit are Soyuz, Space Shuttle, Ares I or a derivative based on Ares I/V concepts, and commercial. Soyuz has been and will continue to be a valuable space transportation system. I do not believe Soyuz is a long-term solution. The United States needs an indigenous system.

Space Shuttle has been the U.S. workhorse for three decades. It has remarkable crew and cargo capabilities. I do not believe Shuttle is the long-term solution.

Private and in some cases government investments have created commercial enterprises focused on space tourism and cargo transportation to the Space Station. These companies should be encouraged, supported, and applauded for their accomplishments.

NASA's proposed budget, if implemented, will result in the United States being totally dependent upon commercial crew space transportation for an indigenous capability to earth orbit. I believe we are a long way from having a commercial industry capable of satisfying human space transportation needs. In my view this is a risk too high and not a responsible course. The commercial crew option should not be approved, and I would like to restate that. The commercial crew option should not be approved.

The United States needs a transportation capability to earth orbit that can be used for several decades. A system that can be the basis for a heavy-lift capability would be advantageous. Considerable resources have been expended, and significant progress has been made in the development of Ares I. I believe the most logical path forward is to commit to a transportation system based upon the Ares I investment. Consideration should be given to the ability to evolve the system to a heavy-lift capability. NASA should be asked to undertake a study to define the required system.

My interpretation of the fiscal year 2011 budget is that the proposed Human Exploration Program is a technology endeavor without an exploration plan. A technology program without focus and identified missions can result in wasteful, non-productive, hobby-shop activities. A detailed explanation—exploration plan with destinations, dates, and implementation plans is needed. Options were effectively identified in the Augustine Committee report.

A factor requiring consideration is that a lunar lander and facilities for extended stay on the moon are expensive, making the lunar option a function of funding availability. I personally am troubled by this observation since I believe human exploration must have boots on the ground. An asteroid landing may be less challenging and expensive than a lunar landing. Again, NASA should be instructed to develop options and recommend a specific exploration plan.

Human exploration beyond earth orbit will require a heavy-lift launch vehicle. I do not believe we need a technology program as a prerequisite. Available budget will determine the heavy-lift implementation plan. NASA should be directed to develop an integrated space transportation plan that will result in the timely development of a heavy-lift launch vehicle.

Human spaceflight requires a capsule for crew support. Given my strong opinion that commercial crew should not be the selected option, the logical starting point in selecting a capsule concept is Orion. Significant investment has been made in Orion, and it should be the basis of a capsule to support Space Station operations and be the basis for initiating exploration beyond earth orbit. A study by NASA to define the crew support capsule is required. Cancellation, excuse me, Constellation should not be cancelled. The NASA study most likely will identify required Constellation modifications. Deferral of a lunar option may be required depending upon available budget.

The technology program identified in the proposed budget lacks definition and focus. However, a technology program largely directed toward resolving critical issues associated with a detailed exploration plan and specifically a human Mars mission is required. NASA, with appropriate outside support, should define the required technology program.

I have cited the need for NASA studies for most of the areas of discussion. A plan A is needed, which is absent from the proposed fiscal year 2011 budget. The availability of plan A will facilitate informed decisions relative to funding and affordability of a human spaceflight program that will be in place for decades.

I would start by applying the $6 billion commercial crew funding, the funding for precursor robotic missions, a portion of the technology funding, and the $2.5 billion allocated for Constellation termination to plan A.

I was asked to comment on the most significant impacts of the changes contained in the proposed fiscal year 2011 budget. Changes as significant as those proposed cannot be implemented without collateral impact. An example is the increased cost identified by the Air Force in their programs.

I believe the most significant impact will be the deterioration in the capabilities of the aerospace workforce. We currently have a government, university, and industry workforce that is a national treasure. Many of the best and brightest are attracted by the excitement and challenge of space exploration.

Decades of experience and investment have been instrumental in building this extraordinary workforce. Without a challenging and meaningful space program, this national capability will atrophy. Assigning responsibility to the commercial sector for earth orbit crew transportation will have a major adverse impact on the NASA workforce.

The loss of capability that has been built over decades will happen quickly. This is not a resource that can be turned on or off. I suspect the uncertainty created by the proposed NASA budget is causing people to evaluate their futures. Good people always have a choice. Rebuilding lost capabilities will take decades.

When the dust settles, I believe the United States must have a space, a human spaceflight program worthy of a great nation as suggested by the title of the Augustine Committee report. In my view the human spaceflight program contained in the proposed fiscal year 2011 budget fails this goal. I believe a program can be developed that will put us on a responsible course to Mars with exciting and challenging intermediate destinations. A program that will utilize the capabilities of the total aerospace workforce. A program of which the current generation can be proud. A program of which the future generations can be inspired. A program that I believe will require some budget augmentation. A program that is worthy of a great Nation.

Thank you.

[The prepared statement of Mr. Young follows:]

PREPARED STATEMENT OF A. THOMAS YOUNG

Chairwoman Giffords and committee members, I am pleased to have the opportunity to present my views on the U.S. human spaceflight program.

The proposed NASA FY 2011 budget represents a significant departure from the current program and raises some important issues worthy of debate prior to setting a course that will define human spaceflight for many decades.

Continuation of the International Space Station and Mars as the ultimate human exploration destination appear to be areas of consensus. While Mars is not explicitly identified, subsequent Administration statements suggest this conclusion.

Areas with significant differences in implementation approach are

1) the method of transporting humans to Earth orbit and specifically to the International Space Station,
2) the need for a detailed plan for human exploration beyond Earth orbit,
3) the development of a heavy lift capability to support missions beyond Earth orbit,
4) the development of a capsule to support astronauts traveling to and beyond Earth orbit and
5) the definition of a technology program focused on specific mission needs.

Approaches being discussed to provide transportation to Earth orbit are Soyuz, Space Shuttle, Ares I or a derivative based on Ares I/V concepts and commercial.

Soyuz has been and will continue to be a valuable space transportation system. I do not believe Soyuz is a long term solution. The U.S. needs an indigenous system.

Space Shuttle has been the U.S. workhorse for three decades. It has remarkable crew and cargo capabilities. I do not believe Shuttle is the long term solution.

Private and in some cases government investments have created commercial enterprises focused on space tourism and cargo transportation to the Space Station. These companies should be encouraged, supported and applauded for their accomplishments. NASA's proposed budget, if implemented, will result in the U.S. being totally dependent upon commercial crew space transportation for an indigenous capability to Earth orbit. I believe we are a long way from having a commercial industry capable of satisfying human space transportation needs. In my view, this is a risk too high and not a responsible course. The commercial crew option should not be approved.

The U.S. needs a transportation capability to Earth orbit that can be used for several decades. A system that can be the basis for a heavy lift capability would be advantageous. Considerable resources have been expended and significant progress has been made in the development of Ares I. I believe the most logical path forward is to commit to a transportation system based upon the Ares I investment. Consideration should be given to the ability to evolve the system to a heavy lift capability. NASA should be asked to undertake a study to define the required system.

My interpretation of the FY 2011 budget is that the proposed human exploration program is a technology endeavor without an exploration plan. A technology program without focus and identified mission uses can result in wasteful, nonproductive, "hobby-shop" activities. A detailed exploration plan with destinations, dates and implementation plans is needed. Options were effectively identified in the Augustine Committee report. A factor requiring consideration is that a lunar lander and facilities for extended stay on the moon are expensive making the lunar option a function of funding availability. I am troubled by this observation since I believe human exploration must have "boots-on-the-ground." An asteroid landing may be less challenging and expensive than a lunar landing. Again, NASA should be instructed to develop options and recommend a specific exploration plan.

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The technology program identified in the proposed budget lacks definition and focus. However, a technology program largely directed toward resolving critical issues associated with implementing plan A and specifically a human Mars mission is required. NASA, with appropriate outside support, should define the required technology program.

I have cited the need for NASA studies for most of the areas of discussion. A plan A is needed which is absent from the proposed FY 2011 budget. The availability of a plan A will facilitate informed decisions relative to funding and affordability of a human spaceflight program that will be in place for decades. I would start by applying the 6B$ commercial crew funding, the funding for precursor robotic missions, a portion of the technology funding and the 2.5B$ allocation for Constellation termination to plan A.

I was asked to comment on the most significant impacts of the changes contained in the proposed FY 2011 budget. Changes as significant as those proposed cannot be implemented without collateral impact. An example is the increased cost identified by the Air Force in their programs.

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The loss of capability that has been built over decades will happen very quickly. This is not a resource that can be turned on and off. I suspect the uncertainty created by the proposed NASA budget is causing people to evaluate their futures. Good people always have a choice. Rebuilding lost capabilities will take decades.

When the "dust settles" I believe the U.S. must have a human spaceflight program worthy of a great nation as suggested by the title of the Augustine Committee report. In my view, the human spaceflight program contained in the proposed FY 2011 budget fails this goal. I believe a program can be developed that will put us on a responsible course to Mars with exciting and challenging intermediate destinations. A program that will utilize the capabilities of the total aerospace work force, a program of which the current generation can be proud and by which future generations can be inspired. A program that I believe will require some budget augmentation. A program that is worthy of a great nation.

ATTACHMENT

COMMERCIAL CREW

I believe the commercial crew option is a risk too high, not a responsible course and it should not be approved.

The U.S. space industry is second to none and has been instrumental in the extraordinary accomplishments of the U.S. space program. My concerns about the commercial crew option are not caused by reservations about the industry capabilities. My concerns are that the space industry alone is not adequate to successfully implement an endeavor as challenging as human spaceflight.

Continuity of the nation's human spaceflight expertise resides within NASA, not an industrial enterprise. NASA has been continuously leading our human spaceflight program for almost five decades. Several companies have been partners with NASA, but not on a continuous basis. I can make the same case for JPL relative to planetary exploration and the Air Force and NRO for national security space.

In my opinion, there is no logic that supports having an industrial enterprise totally responsible for crew transportation to Earth orbit with NASA defining safety requirements and general oversight.

We actually tried a similar approach in the 1990s. The Air Force implemented a program called "Acquisition Reform." System responsibility for national security space programs was ceded to industry under a contracting approach called Total System Performance Responsibility (TSPR.) Air Force and NRO project managers were told to step back, to not interfere and to let industry have total responsibility. Additionally, the Air Force and NRO essentially eliminated their system engineering capabilities since the responsibility would reside with industry.

The results were devastating and the adverse impact is still with us today. Good project managers and project management personnel left and an exceptional systems engineering capability was eliminated. Projects were a disaster and TSPR was judged by all to be a total failure.

Problems were not isolated to one project or to one company, the impact was systemic. As examples, FIA managed by Boeing was cancelled after the expenditure of about 10B$. SBIRS High, managed by Lockheed-Martin, has been referred to as "a case study in how not to execute a space program." NPOESS, managed by Northrop Grumman, is a story that is still evolving. On average, programs implemented using this approach resulted in half the intended program for twice the cost and six years late.

NASA implemented a similar approach called "Faster-Better-Cheaper." Mars '98 is the most significant example of this approach. Mars '98 was a total failure with the loss of the orbiter, lander and two probes. The orbiter managed by Lockheed-Martin, under contract to JPL, failed because of confusion between metric and English units. This confusion resulted in errors large enough during Mars orbit insertion to cause the spacecraft to enter the atmosphere and be destroyed. These same errors were prevalent during midcourse corrections implemented on the trip from Earth to Mars without a cause being determined. Had the JPL institutional navigation capability been applied to understand these midcourse errors, I believe they most likely would have found the cause and implemented corrections to prevent the failure. They were excluded from the management of Mars '98 because of the "give the contractor the responsibility" concept. This is an example of how NASA's continuity of expertise could have been applied to an important and challenging project.

An Aerospace Corporation study documented 11.2 B$ of total mission failures during the 1990s.

NASA is supporting new industrial enterprises to provide cargo transport to the Space Station. This commercial cargo approach has the potential to develop new commercial space enterprises. While this is a reasonable concept, performance has yet to be demonstrated. The proposal that this cargo capability, which has yet to be proven, can be extrapolated to include commercial crew is not credible.

An argument is made that NASA will specify human safety requirements for use by potential commercial crew companies. This is necessary but far from sufficient to assure mission success. Today, space projects do not fail because of the items that would be contained in the safety requirements document. I doubt the requirements would say "don't confuse metric and English units," or "don't write down a wrong number to be used in the guidance equations," which resulted in a Titan IV failure, or "don't let the foam hit the Shuttle wing leading edge." Because humans are involved, errors will happen.

Success results when problems are successfully managed. I believe successful management occurs when the continuity of expertise of NASA or the Air Force or

the NRO is combined with the implementation capability of industry. The application of this combined capability with the resulting checks and balances and constructive technical debate is the foundation of our extraordinary success.

There is much discussion as to whether commercial crew is cheaper or, in the end, will cost more. Similar debates are occurring relative to schedule. These cost and schedule issues deserve resolution; however, I believe the most important issue is "Will the commercial crew concept be successful?" I do not believe the probability of success is sufficiently high to justify commercial crew as a responsible option. It is an option, that if not successful, will result in the U.S. having no space transportation for two decades or longer.

Chairwoman GIFFORDS. Thank you, Mr. Young. We appreciate your service and your testimony today as well.

Votes will be called in a couple of minutes, but we do have time get in a couple of questions, and we are going to bring our first round, and the Chair recognizes herself for five minutes.

USE OF FY 2010 FUNDS FOR CONSTELLATION TERMINATION

Mr. Cooke, I would like to read an excerpt from the 2010 Consolidated Appropriations Act, and I quote, "None of the funds provided herein and from prior years remain available for obligation during fiscal year 2010 shall be available for the termination or the elimination of any program, project, or activity, underscore or activity, of the architecture for the Constellation Program."

I would like to go through a short list of some of the actions that NASA has recently undertaken or maybe I should say activities that NASA has terminated. NASA cancelled the Ares V Phase I Concept Definition and Requirements Development RFP, NASA cancelled the Altair Lunar Lander Concept Design Contract RFP. NASA cancelled the Kennedy Space Center Exploration Ground Launch Services RFP, NASA has stopped allowing Ares prime contractors to make planned hardware subcontract awards for both the Ares Instrument Unit production and Ares Upper Stage production contracts.

So, Mr. Cooke, I would like you to explain if you can how NASA's actions are not in direct contravention with the unambiguous intent of the Congress and in some cases the direct law and the prohibition of the termination of any Constellation activities.

Mr. COOKE. Yes. I can address these. We actually are continuing with the major work on the contracts and are making—and have—we have had a number of decisions where we were asked whether we continue or not. We do—we are continuing to work. There are a number of things that we have not started, some of which have become outdated in terms of how we started them out.

Others—we also have the effect of the enacted 2010 budget and some budget changes in 2010, that—for one we had a $50 million budget, general budget reduction, we had actually an internal NASA rescission that was to fund needed infrastructure investments. We also had a tentative agreement with one of the contractors for cost sharing that actually we ended up not being able to put in place.

The continuing resolution that we started with this year did not allow us to get things started, for instance, on some of the lead items, so we were not able to start those when we would have. So there are some that are in that category, and we are reassessing

the budget reductions that we have seen. So that is a part of things that we have not started.

We—in terms of the Altair and Ares V study contracts, we did have proposals in on those, and we actually had them on hold since last year before—when we were going through the transition period and learned of the upcoming Augustine Commission, we thought that we should hold those at that time. So we have been holding those for a year.

And we just a little while back we got to the point where we felt that they were—because we didn't have funding to support lunar investments, we stopped the Altair, and in terms of the Ares V, it—because of studies that have gone on over the last year, we have evolved in our thinking and felt that we should re-look at what we went out with. So we think that in the coming, actually in the coming months that we will put out another request for proposals on studies, study contracts for heavy lift.

Chairwoman GIFFORDS. Mr. Cooke, we have had the Administrator state to us that there haven't been changes, that NASA is complying with the direct law, but obviously we have examples where that is simply not the case, and there is a deep concern, and Congress put that language in there specifically for a purpose. We wanted time to allow for careful and deliberate review of any Administration's proposal that was going to significantly change or—basically we have a program of record. We wanted to make sure that that program was allowed to be carried through and that we could analyze that record based on the information that Congress had intended.

And, you know, and we are deeply concerned. We have brought it up a variety of times with, you know, leading officials at NASA, and I guess, I think before I am going to turn the floor over to Mr. Olson, but I would just suggest that NASA spend a little less time figuring out ways to wiggle out of some of these contracts and to figure out how to negotiate this without thinking that we are going to notice and more on following what the direction of the Congress and the United States people had in mind.

So with that, Mr. Olson.

STATUS OF CONSTELLATION PROJECT

Mr. OLSON. Thank you, Madam Chairwoman.

In its justification of the fiscal year 2011 budget the Administration's painted the Constellation Program as hopelessly behind schedule and over budget, and I think there is an analysis that suggests that the goal of landing on the moon by 2020 was in jeopardy. Both the goal of Ares I, taking Orion to the ISS, NASA always asserted that it could be achieved by 2015.

Mr. Cooke, would you speak to the basis of the allegations that the Constellation was over budget.

Mr. COOKE. I can speak to the budget numbers and predictions of the program that I have been—that I am responsible for. Until the 2010 enacted budget, we felt that we were on a course. Although we had schedule risks, we felt we were on a course to March, 2015. Since—mentioned in the last response, my last response to a question that we had had some reductions in 2010 that would—at this point the March, 2015, is probably not possible

but—and we have just been through preliminary design review and have in front of us based on that data the work to develop costs and schedule that goes with that baseline to understand exactly where we are in terms of where we would end up.

Mr. OLSON. And just to confirm I understand what you are saying, Mr. Cooke, so that NASA was on track for Ares I by 2015, but then budget reductions last year got them off track. Was that—is that a fair assumption or fair understanding of what you said?

Mr. COOKE. That is our assessment, and of course, you know, there are other assessments and other evaluations, but that was the program's assessment.

Mr. OLSON. Thank you very much, and Mr. Young, would you give us your perspective on the ability of NASA to develop Ares I and Orion to accomplish just the ISS mission?

Mr. YOUNG. First I should be clear, I have not done a review of the program and did not participate in that, but I, you know, have been a close watcher, I guess, of the activity maybe is the way to say it. I think that it is reasonable to assume that having invested $9 billion in Ares I and Orion, and I am setting the lunar aside because I think that is a tough challenge. I don't want to—I want to be clear about that, but only talking about Ares I and Orion, having invested 9 billion, having successfully had a PDR, not being terribly far from a CDR, would give—and Mr. Cooke is the right person to answer this, but not having—seeing great problems that have come out of the PDR, then I think it is reasonable to assume that there is credibility to the Ares I/Orion approach and concept and design.

And I think, again, even if you use some of the larger numbers that were in the Augustine report or other locations, it is not a stretch to believe that an Ares I/Orion system can be made to work in close to the current budget. So in my view when I have thought about it a lot and looked at the alternatives, no alternative strikes me as being credible, as credible as Ares I/Orion as the basis for a space transportation system to low-earth orbit and to the Space Station.

So I think deviating from that course until we have maybe done all of the studies the Doug Cooke is talking about would just be a significant mistake.

FUNDING TERMINATION OF CONSTELLATION

Mr. OLSON. Thank you for those comments, Mr. Young, and I have one final question that is for you, Mr. Cooke.

I understand that NASA is requiring Constellation contractors to fund termination liability out of existing fiscal year 2010 funds. This would be a blatant violation of the fiscal year 2010 Appropriations Law.

I also understand that insufficient funds were included in the fiscal year 2011 budget request for the Constellation contractor termination liability. Can you assure me that NASA will not seek to use existing appropriations for termination liability unless specifically authorized by Congress?

Mr. COOKE. This is an area that is very sensitive. It is—there are laws that we are working with and anti-deficiency is one of them.

We are not changing our contracts, and we have not directed anything other than what is in the contracts to our contractors.

Mr. OLSON. I know I am over my time but just one final question for you, Mr. Cooke. Can you assure me that should Congress agree to the termination of any Constellation Program or activity that NASA will provide sufficient termination liability funding at that time?

Mr. COOKE. I am sorry. I didn't understand that.

Mr. OLSON. Okay. Should we agree to the termination of the Constellation and all the program activities there, can you assure me that NASA will provide termination liability funding at that time?

Mr. COOKE. We have—we are not, as in the appropriations language and law, we are not terminating contracts, and we—but we are funded at the levels we are for our contracts at this time.

Mr. OLSON. Thank you very much. I just want to follow up on my Chairwoman's comments. I mean, we are having a great debate here about the future of our human spaceflight program, but the marching orders now are Constellation, and that is what the appropriations bill language is in there, and until that changes some time later this year, that is it. I mean, from my perspective Constellation, Constellation, Constellation.

I yield back my time.

Chairwoman GIFFORDS. Thank you, Mr. Olson.

The Chair recognizes Ms. Kosmas.

NASA'S INSPIRATIONAL MISSION

Ms. KOSMAS. Thank you, Madam Chairman. Thank you, gentlemen, for being here today.

While I certainly appreciate the need to identify and develop the missing capabilities for going to Mars, I am very concerned that in the meantime we are giving up our current capabilities to reach space without any plans for the next mission, and that this downtime will not only affect our workforce but also our national security. And I want to echo the comments made by the Chairwoman with regard to this being unique in its inspirational aspect.

I, too, received a letter from a constituent. She is nine years old. Her name is Hero, and she has been wanting to be an astronaut for many years and is concerned about the loss. This echoes, I think, throughout the community of young folks who we want desperately to encourage to be interested in science, technology, engineering, and mathematics. So I am greatly concerned about it.

More currently, however, I am concerned about the job loss at Kennedy Space Center.

FUTURE OF NASA WORKFORCE

So, Mr. Cooke, at the February 25 hearing with this committee the NASA Administrator stated that civil servants who support Constellation should feel secure that NASA has exciting and meaningful work for them to accomplish after Constellation, and you repeated this in your testimony, but I need to ask you why should they feel secure? Can you provide any specifics on work that human spaceflight proposals currently before us will have waiting

for these, for this unique workforce if Constellation is cancelled? What about the Space Shuttle operations personnel who are planning to transition to Constellation, and what work will be waiting for them?

Mr. COOKE. Representative Kosmas, the—as I stated, there is funding and will be funding to support civil servants, and there—in our particular budget and explorations budget next year we have 483 million more than we have this year. It a shift in direction, and it is a shift in the work that will be done, but the civil servants will be——

Ms. KOSMAS. I think that is the question that I am trying to get to the bottom of, Mr. Cooke, is aren't you allocating funds that will be used for a different set of skills perhaps than those people whose jobs I am worried about as we speak?

Mr. COOKE. Skills are always part of the discussion when there is a shift in the type of work being done. There is significant technology work that is possible at KSC and has been done there in the past in terms of cryo management and resource utilization. There are skills there.

Ms. KOSMAS. Okay. I am going to have to move on because I am going to run out of time, and I want to make sure I get this question in.

COST OF ARES I

There seems to be, and this follows up on the questions asked to you by Mr. Olson, there seems to be a good deal of confusion on what it would cost to launch an Ares I once it is developed. In other words, the marginal cost. This is something I just wanted to get on the record, so a yes or no from you, Mr. Cooke, is all that is required.

NASA stated last year that when Ares I is operational in fiscal year 2016, its marginal costs based on a rate of two flights per year will be about 176 million per flight. Now that you have completed the Constellation Program preliminary design review, has that number changed significantly, or is it still a reasonable estimate?

Mr. COOKE. In terms of marginal cost it is still a reasonable estimate.

NET CHANGE IN WORKFORCE

Ms. KOSMAS. Okay, and then my last question is how many net jobs could you guarantee would be created by NASA's decision to procure commercial crew services given the nationwide job losses that will result from the retirement of the Shuttle Program and the cancellation, proposed cancellation of Constellation? We have heard numbers proposed by the commercial industry, but have you independently validated those estimates, and can you tell me how many Constellation jobs will be lost, including those additional jobs that would be created if Constellation continues? Congress needs this information if we are going to properly assess the Administration's proposals.

Mr. COOKE. Yes, and I would like to follow up with those, with more detail on those. I don't have all those numbers at hand, but I would say that I don't know, I don't have an assessment of what

jobs would be created with the commercial approach to this. Until we had competed and had chosen or selected for—in agreements with specific companies. So I don't have that number.

In terms of contractors nationwide, there are over 8,600 contractors working on Constellation.

Ms. KOSMAS. Okay. I just want to say that for the record it seems to me that the current plan, not only does it lack vision, destination, and architecture, but it seems to lack—and inspiration, but it seems to lack the attention and respect of the workforce that we were promised we would get from NASA and from the Augustine Commission and frankly never received.

So from my perspective it is obviously a very significant issue as we move forward.

Thank you.

Chairwoman GIFFORDS. Thank you, Ms. Kosmas.

Mr. Rohrabacher.

BENEFITS OF PRIVATIZATION

Mr. ROHRABACHER. Thank you very much, Madam Chairman, and this debate is a bit perplexing. It just seems to me that there are different role reversals going on here in terms of what people actually believe is the best way to structure our society and our society's goals and obtaining those goals. I always thought that it was the Republicans and others who depended on the private sector rather than a government workforce to achieve certain ends, and it was the Democrats that wanted to socialize different services. It seems to me was have a role reversal here.

Let me just note that we have faced these decisions before as to whether or not we would rely on commercial enterprise versus government-run operations. The building of the railroads, for example, Abraham Lincoln wisely decided that we would be providing land to the railroads for building the railroads. He did not create a government railroad company that was actually—or a government railroad agency that decided to develop railroads and the railroad transportation in our country.

Similar, when we came to the airplane age, there were contracts that were given for delivering the mail to private companies rather than having a government agency that became the government airline agency.

And today we are now on the verge, I believe, of actually a huge step forward into space where the large numbers of people can be engaged in enterprise in space, and we have the argument instead that, no, this must be a government-based operation because basically it might hurt the NASA workforce.

And I went down, Madam Chairman, I went down to see Space X a couple of weeks ago just to see how far they were along on their private commercial alternatives to Ares, and let me tell you, I was shown around the plant by one employee, but he had—he was actually the manager there on the floor of getting these jobs done. And I remember when I visited NASA facilities, they have about a dozen people walking around you trying to basically curtsey to you and pat you on the back and do everything they can, and none of them have any other responsibility except to promote

the NASA workforce or the NASA job there versus any line responsibility.

And maybe that is why when you have NASA doing something it costs $9 billion to produce no new technology and over at Space X they have built their own rocket engines, they have had a whole new system, all new technologies, and they have done it on just a miniscule amount compared to what NASA has already spent on the Ares Project.

Listen. If we are going to be in space, we had better do it cost effectively, and cost effectively is not relying on the government. We have learned that over and over again, whether it was the railroads or private airlines. It is better to go with commercial and private people than a Federal bureaucracy, and it is not efficient the other way.

Now, people say we can't be sure of anything. Well, there is nothing for sure. One thing is for sure, that we built the Shuttle, we built the Shuttle, and I remember when that debate came down, and that has cost us $1 billion every time we put it up. Every single time when we put it up. There might have been some other transportation systems that have proved more effectively in the idea of getting people up into orbit rather than the Space Shuttle System.

Chairwoman GIFFORDS. Will the gentleman yield?

Mr. ROHRABACHER. As long as it doesn't——

Chairwoman GIFFORDS. Well, I would just—I would like to get—if the witnesses——

Mr. ROHRABACHER. Actually, we need to get their responses.

Chairwoman GIFFORDS. Well, yes, we would like to hear from the——

Mr. ROHRABACHER. Absolutely.

Chairwoman GIFFORDS. Absolutely.

Mr. ROHRABACHER. I am sorry.

Chairwoman GIFFORDS. The Chair recognizes Mr. Young.

Mr. ROHRABACHER. It is just that I am the only one who seems to be presenting these arguments.

Chairwoman GIFFORDS. And this is why we have them. Mr. Young.

Mr. ROHRABACHER. Mr. Young, let us go to you to answer this basic philosophical question. You were involved with a private company. Does—is Atlas missiles, are they—rockets. Are they so limited that they are not going to be able to pick up some of this weight that we need to put up into space? Is—was your company less competent than NASA to move forward and run some sort of operation that could put human beings into space?

Mr. YOUNG. Let me see if I extract a question out of that.

Mr. ROHRABACHER. All right.

Mr. YOUNG. Let me comment because it is an important issue that you are identifying. First off, let me tell you Atlas is not commercial, and I will come back to that in a minute. Bear with me. I will come back. You know, I am a product of the aerospace industry, so I have a teensy bit of knowledge about the aerospace industry.

My—I am strongly against commercial crew, and let me tell you why. Okay. I am not—I believe our aerospace industry is second to

none. I—my issues are not with aerospace industry, either the more mature or the developing. My issue is that I do not believe the aerospace industry alone can successfully execute a program as challenging and complex as human spaceflight.

And let me see if I can give you a little bit of why I say that. The continuity of expertise that we have in this country as to how you do human spaceflight is with NASA. Not with any company. Companies, you know, different companies come in and out on the programs, and they do well, but they do well as a partner with NASA, not when we turn the total responsibility over to the industry.

Now, let me give you an example. We tried this in the '90s. We actually tried it wholeheartedly, and the Air Force implemented something they called Acquisition Reform. Fundamentally what they did was they took system responsibility for national security space programs, and they ceded it to industry, and they did it contractually. They did it with something that was called Total System Performance Responsibility or TSPR, and in essence they told their program managers, look. You stand back, get out of the way, sit in the back of the room, don't ask questions. We are turning this over to industry. They went further than that. The government had an enormous systems engineering capability. We terminated it, and we went about implementing a collection of the most important NASA security space programs that this country has.

The results were devastating, and the adverse impact is with us today. In essence what happened was good project managers left because if they can't influence what they are doing, they don't want to do the job. As I mentioned earlier, good people have a choice. The systems engineering capability was eliminated, which was a horrible item, and the projects were a disaster, and I don't think there is anybody who believes that TSPR was anything other than a total failure.

And let me give you some examples. This was not isolated. It was systemic. Boeing, FIA, $10 billion cancelled. SBIRS, program with Lockheed Martin, there is a quote, "If you wanted to find out how to not manage a space program, this is it." NPOESS is one, and actually, I went back and looked at it. Of these programs for the 1990s not one of them except Wide Band Gapfiller has been launched. These all started in the late '90s and not one has been launched to date.

And in essence, if you take and average those programs, which you will find is the following, today we are getting half of the program content for twice the money six years late. So you say, now why do I think—and I could go on with NASA, different—but I want to make it short, the Aerospace Corporation actually documented, there is a report, that there were $11.2 billion worth of total mission failures in this time period. I think you can trace it to this, and the reason is that the industry is not constituted to do these things by themselves. We have a technique where if you take the expertise of NASA and the implementation capability of industry, and I am not in favor of a NASA arsenal, but if you take the institutional capability of NASA and you take the execution or implementation capability of industry, you have got kind of the beginnings of the keys to success.

What this results in good checks and balances, good debate, good mission assurance practices, and I think she is trying to stop me but——

Chairwoman GIFFORDS. It is a great debate. Hold that thought.

Mr. YOUNG. Okay.

Chairwoman GIFFORDS. We are going to—votes have been called, so——

Mr. YOUNG. Okay.

Chairwoman GIFFORDS. —we are going to call on Mr. McCaul. We are going to—if we have enough time, we are going to call on Ms. Jackson Lee. Then we are going to recess and then come back, but I want to make sure that we get the members when we have them, if we have enough time.

Mr. YOUNG. Okay.

Chairwoman GIFFORDS. Yes, and a second round.

Mr. McCaul.

SPACE AS A NATIONAL SECURITY ASSET

Mr. MCCAUL. Thank you, Madam Chair, and let me follow up on this because that is excellent testimony. You make great points about the Air Force trying to do this and it didn't work. This is a national security asset. I don't think you can completely turn it over to commercial spaceflight. It has national security aspects to it, military aspects to it. I don't see the transition here either. I mean, and Mr. Cooke, maybe you can educate me or enlighten me as to how or when this gets turned over to commercial spaceflight. I don't see a transition period, something that we have invested 8, $9 billion in, and then we are going to just hand it off to commercial spaceflight as if it is going to be a seamless transition. I don't think that is going to happen.

And the other question I had was was the Department of Defense consulted on this decision? Because it seems to me we are putting the United States in grave danger here, at risk by this decision.

Mr. COOKE. Representative McCaul, I have not personally been in discussions on that. I know that my Administrator has been in some conversations. I don't know the extent of those.

Mr. MCCAUL. Well, and I think the answer is that they weren't, and I think we have had several people from the Department of Defense come out and say, you know, we would have liked to have been at the table talking about this because it does impact our defense capabilities and the national security of this country, and I think that was a big mistake.

Mr. Young, do you have any comments on this transition period and also on the national security, you know, aspects?

Mr. YOUNG. I honestly don't know any of the details of the deliberations. As I made in my comment, I do know that anything as sweeping is what we are talking about, has significant collateral impacts, and so, you know, it is important to understand those impacts.

Relative to the transition, see, I am not convinced that transition is anywhere in the near future because I think that we have a formula for how to make these things successful, and it is a NASA-industry partnership. It is not a turn-it-totally-over-to-industry

kind of a solution. So I don't look at a transition, you know, down the line but when we talk about NASA doing it, you know, NASA does it fundamentally with using the strengths of our aerospace industry to implement these programs.

Mr. MCCAUL. So do you think that there is going to be a gap in human spaceflight now? Certainly we will have to rely on the Russians and the Chinese far more than we do today.

Mr. YOUNG. Well, if—my personal opinion, yes, because I do not think there is a sufficiently high probability that commercial crew will be successful. So I think we are looking at decades with no, you know, with no exploration.

I shouldn't take your time, but I, too, have—I have a seven-year-old grandson, and you mentioned Noah, named Spencer, who has been to a Shuttle launch, who goes to the Air and Space Museum with me, and to be honest with you if we implement this budget, I hesitate saying this but being as it got introduced I can build on that, I am worried how am I going to—and by the way, whenever I go visit him, he is in Northern Virginia, his father is a commander in the Navy. When I go visit him, he always has another book on space for us to, you know, look at, and I am really wrestling with, seriously, how do I tell him that if this program is implemented, the next time NASA flies in space he could well be 30 years old.

Mr. MCCAUL. Yeah. I think we are letting down our kids. This has been a great program for, you know, science and math, and the technology spin-offs that have come out of this—one of the best investments of Federal dollars that we have had, and I am concerned about our ability to compete globally, not only from a defense standpoint but from a technology standpoint if this decision goes forward.

And with that, Madam Chair, I yield back.

Chairwoman GIFFORDS. Thank you, Mr. McCaul.

Unfortunately we only have about 3 minutes remaining until we—the vote will be past due, so what I am going to hopefully respect is—or request is if Ms. Jackson Lee and Mr. Perlmutter would like to return, we will have a second round of questions, and if our witnesses wouldn't mind waiting a few minutes, we will go vote and hurry back as soon as possible.

And with that our committee is in recess.

[Recess.]

Ms. EDWARDS. [Presiding] The hearing will be in order, and I thank you very much for waiting, and we will reconvene, and we will begin with questions from our visitor today but no stranger, Ms. Jackson Lee from Texas.

COLLABORATION ON BUDGET

Ms. JACKSON LEE. Thank you, Madam Chair, and it feels good to be in this room again as a former member of the Science Committee, and I thank the subcommittee and Chairwoman Giffords for her courtesies and to the staff as well for your courtesies. I thank the witnesses as well.

I will start with Mr. Cooke. I think you have gleaned from the number of members who have been here that the majority on both sides of the aisle have a strong commitment to NASA and human

spaceflight exploration. My question to you and I have always felt that when the Administration and Congress works together we are moving toward a home run, a home run for the issue that we are working on and certainly a home run for the American people.

Is there a sense that NASA would be welcoming to the ideas and suggestions of Members of Congress who have oversight and others who are advocates for NASA? Are we still in a realm—there is a budget process moving forward, there is an appropriations process that is still in play. Is the NASA headquarters open to engagement and working with us?

Mr. COOKE. In very simple terms, yes, we are definitely interested in pursuing engagement on this budget with Congress.

Ms. JACKSON LEE. And I pretty much have listened to your testimony, so Mr. Young, I am going to probe you and try to glean some additional points.

First of all, I have introduced legislation, and I thank you, Mr. Cooke. I, too, think that we are best when we are collaborating. I think in hindsight we can look back on what the analysis was to put forward the present budget, and I would think that there was probably issues that drew and caused the budget to be drawn as it is presently, but I will tell you as we go through this process I think you will see more and more issues, the Administration will see more and more issues that will lean toward what I have seen as the bipartisan position on this committee so far from listening to this testimony, that Congress wants to move forward with the human spaceflight. It is valuable to America.

WEAKNESSES OF PRIVATIZATION

But I do want to ask Mr. Young, I introduced legislation to address the question of NASA as a national security asset. So let me quickly have you assess, move into or merge into that point and the point that you made that I thought was so potent, and that is the start and stop of the commercial, private sector, to no fault of their own. Companies go in and out of business, but if we are to have a continuous stream of thought and intelligence and commitment and if you will, the continuation of knowledge, the holding of knowledge that is not loss, is this not the government the best receptacle, if you will, for that?

The second point if you can reflect, and Mr. Cooke, you should as well, my enthusiastic friend of this committee mentioned the whole commercial opportunities and there are, but I am reminded tragically of some of the work that one private entity did, Blackwater, compared to the military, and we all have our ups and downs, but some things warrant not privatizing, at least in its totality.

Would you comment on that, Mr. Young?

Mr. YOUNG. Okay. Let me really come to your first question first because it is quite a good question. I believe that the, I am going to call it the continuity of expertise in human spaceflight, resides with NASA. I could make a similar comment about the continuity of our expertise in planetary exploration is at JPL, and the continuity of our expertise in doing national security space programs is in the Air Force NRO and Aerospace Corporation.

These are organizations that the country has deliberately established and invested in that have the full spectrum of the successes and the problems, the lessons learned, and they go forward.

Industry plays a very important role, and the thing I was trying to make with Congressman Rohrabacher, I am—I think our industry is second to none, so my comments have nothing to do with the deficiencies in industry.

Ms. JACKSON LEE. Absolutely.

Mr. YOUNG. It is just if we take human spaceflight just as an example, and I don't know how much I do from memory but Doug could help me, but if we go to Mercury, it was McDonnell Douglas, you know, if we go to Gemini, it was also McDonnell Douglas. If we then go to Shuttle, it was North American Aviation. If we go to Orion, I guess it is Lockheed Martin. They are all extraordinary companies, but they don't have the continuity, and I could do the same thing with the other activities.

So it is my strong belief that the formula for making these things successful is to take that—is to not have it a government program and not have it a commercial program, have it a national program, and that means that the continuity of expertise that NASA has gets combined with the implementation capability that industry has, and it is that combination together that makes these things successful.

And none of us are smart enough that we don't need checks and balances, and we don't need healthy technical debate about how is the best way to do that or how is the best way to do the other, and it is this integration of the activities that make these things successful, and my personal belief is I don't think that industry alone can make this program a success.

So I do not believe we will have a success if we, you know, if we don't go in that particular direction. So, you know, the Blackwater or what have you, I don't know enough of the details there. I am, again, I am not in favor of, as I mentioned earlier, a government arsenal where we do it all in-house, but I really want to highlight the fact that in my view it is this integration of these capabilities where the Doug Cookes have healthy debate and interaction at the PDR with counterparts in industry. And it is out of that process that we really make these things to succeed, and I personally believe if we pursue a commercial crew where it is basically turned over to industry, I think we will be making a colossal error. I mean, I don't think it is a close call.

Ms. JACKSON LEE. Madam Chair, if you would indulge me just one quick question, please.

Ms. EDWARDS. Very quickly.

PROTECTING NASA'S ACQUIRED EXPERTISE

Ms. JACKSON LEE. To Mr. Cooke, could you comment on whether or not people who are associated with Constellation are being terminated and whether or not there is now just a hold on those positions or whether we are losing those positions, and just quickly on that national security issue. Is there some value to NASA intelligence that they have, knowledge that they have, that it is an asset that we should protect.

Thank you, Madam Chair.

Mr. COOKE. Yes.

Ms. EDWARDS. Thank you, and then we will go to our second round of questions.

Mr. COOKE. We are not—we at this point are not terminating, and we certainly are going to continue with the civil servant participation in our programs. In terms of that we are—this year we are not terminating.

Ms. JACKSON LEE. National security?

Ms. EDWARDS. Thank you, Mr. Cooke.

FUNDING TERMINATION OF CONSTELLATION

We will go to our second round of questions, and I would like to begin and continuing along that same line, Mr. Cooke, at yesterday's House Appropriations Hearing NASA Administrator Bolden was asked whether NASA was taking any actions in fiscal year 2010 that would unduly delay or impact the Constellation Program if Congress ultimately decides to continue Constellation in the 2011 budget. At the hearing Administrator Bolden assured the appropriators that NASA wasn't doing anything in 2010 that would result in any significant delays or impact to the Constellation Program.

However, now we are hearing and the Administrator didn't disavow it at yesterday's hearing that NASA may be preparing to send letters to Constellation contracts as soon as the end of this week. Those letters would call on contractors to hold back sufficient sums from their fiscal year 2010 funding to cover termination costs in fiscal year 2010, despite the fact that the 2010 Consolidated Appropriations Act specifically said that no Constellation terminations could even take place until a subsequent Appropriations Act is enacted.

So, Mr. Cooke, won't the impact of those letters be such that in order to comply the contractors will still have to stop or delay work on Constellation that was planned for FY 2010, despite the Administrator's assurances to the contrary?

Mr. COOKE. In terms of communication with the contractors on Constellation, we are not going to tell them anything that isn't in their contract.

Ms. EDWARDS. But under what authority do you have to do that if the—if this, you know, any such actions that would go to the 2011 budget was not required or specified in the 2010 budget?

Mr. COOKE. We are not directing the contractors to take actions.

Ms. EDWARDS. So what will be the content of the letter then?

Mr. COOKE. I haven't seen the letter, so I don't—and I don't know that they exist at this point.

Ms. EDWARDS. Are you aware of any human spaceflight, major human spaceflight programs over the past 30 years that required contractors to set aside each year the funds needed to cover termination while the project is still underway and still authorized and appropriated as now is being contemplated?

Mr. COOKE. The contracts that we write are not different today as they have been. I probably ought to take that for the record to make sure that we get appropriate procurement and legal answers to the questions.

Ms. EDWARDS. Well, then we will expect then that we will receive a response to this set of questions, though, on the—for inclusion in the record.

I wonder if you could tell me whether the new requirement is inconsistent with past practices with the fiscal year 2010 Appropriations Act?

Mr. COOKE. The—in going forward we are, once again, we are not changing the contracts. I mean, these are the contracts that have been in place, and so we are not directing changes.

Ms. EDWARDS. But if a contractor were asked for a—in fiscal year 2010, to set aside a part of its contract for the purposes of preparing for termination, where would that authority come from? I mean, it didn't come from Congress.

Mr. COOKE. We are not directing them to do anything other than what is in their contract. I mean, these are the contracts that have been in place. I am sure I answered the question.

Ms. EDWARDS. Then let me just conclude by just requesting that you prepare a full answer to this question for our records.

Mr. Young, do you have any comments about that? Have you—in your experience have you experienced a contract where you were required under one appropriation or authorization to set aside money in preparation for termination of the contract? Is that something that you have experienced before?

Mr. YOUNG. That is not an issue I have been thinking about the last little bit, so I am going to beg off and tell you—it is a good question, and I think you deserve a, you know, a response to it. There is clearly—how it should be done is not ambiguous. I mean, maybe I can say that. I mean, there are clear, you know, statements in the FAR, and there is clear contractual requirements as to how it should be done.

Being as I haven't really kind of let that wrestle through my head I don't want to maybe get you off track.

Ms. EDWARDS. Thank you very much. Okay.

STATUS OF TIGER TEAMS

Mr. Cooke, I want to go to, you know, following really along the same lines, I would appreciate it if you would provide any or you can provide any new information today on the responsibilities and reporting schedules of the tiger teams that have been established. I mean, one—that is helpful because one sentence in your prepared statement sort of stands out, in which you say that, "The data assembled by the study teams will equip NASA with vital and substantive information that we will need once the new fiscal year begins and once NASA embarks on its effort to implement the 2011, budget request."

Your statement goes onto the project completion, to project—to project rather the completion of a majority of the team's work by the end of the third quarter of fiscal year 2010. So based on the fact that so much is still unknown and will remain so potentially through the end of this fiscal year, how can Congress be reasonably expected to evaluate the appropriateness of NASA's exploration budget?

Mr. COOKE. We will—we are—we do have these teams in place, and it is part of the budget planning process in terms of laying out

the processes and understanding how these programs would be put in place. We can, I mean, we will share information at logical points in that development as part of the budget process.

Ms. EDWARDS. Thank you.

Mr. Olson.

FILLING THE HUMAN SPACEFLIGHT GAP

Mr. OLSON. Thank you, Madam Chairwoman, and Mr. Cooke, a question for you, sir. Just prior to the decision to cancel the Constellation in February, NASA was still on a path for the Space Station by March, 2015. In fact, earlier in our first round, I mean, you confirmed that that was still a good number. At the February 1 teleconference brief to the media on NASA's budget request, the Deputy Administrator Lori Garver said that for planning purposes NASA expected a crew, commercial crew transport system to be ready to go in 2016.

And all of us aren't interested in lengthening this gap between human spaceflight services in the United States, and, again, March, 2015, is what Ares would have done. Commercial at best now we are hearing some time in March of 2016.

Can you resolve—how does that increase or—it sounds to me like it increases, you know, our gap, and why is that in our country's national interest, our security interest to increase the gap when we have got a program of record that is working right now?

Mr. COOKE. In terms of the comparisons, the, of course, there was the Augustine Committee that delivered their independent view of it, and their estimates were different than the program's. In terms of the readiness of Ares and Orion, I can only speak to my understanding of the program data that I have seen, and that is why I said what I did on the 2015 date, and that is based on development of data from the contractors and evaluating our internal schedules.

And in the March, 2015 date there has been schedule risks that I think we have talked about in the past. In terms of—I would not want to speculate on what might come of commercial crew because that will require that we put out solicitations for that work, and really understanding the proposals and what is possible for what amount of money is what is required in my view to assess that.

Mr. OLSON. Thank you for that answer. So kind of in summary I think you would be saying that certainly with Ares I as part of the Constellation you have got a much better comfort level with what is capable as opposed to these commercial operators who right now are unproven. Is that a fair statement?

Mr. COOKE. I can really only speak to my understanding of the Constellation Program.

DELAYS TO THE CONSTELLATION

Mr. OLSON. And, Mr. Young, one more question for you. Given the agency's decisions for fiscal year 2010 to refrain for initiating new work not currently under contract and to refrain from expanding the scope of any work that is currently under contract, what is the scale of the delay to reach IOC if Congress were to direct continued development of Constellation?

Any thoughts on that, Mr. Young?

Mr. YOUNG. Yeah. I don't have the, you know, the detailed knowledge or study to really, you know, really comment on that. I do think that there is one factor that, you know, one, the circumstances have somewhat changed in that we said that we are going to continue Space Station at least until 2020. So, you know, one of the—and, in fact, I, you know, even read that out of the International Partners meeting there was discussion of 2028 there. So we are talking about—and you would kind of have the feel that if Space Station is productive, continuing to be successful, it is going to be hard to not continue that to operate.

So I think we are now talking about a system to support transportation to and from the Space Station that is not measured in the part of the next decade, what we are talking about for a decade or even, you know, another decade beyond that. So in my view that somewhat changes the equation as to how you evaluate what is the best space transportation system to go back and forth to the Space Station.

Mr. OLSON. Yes, sir. Thank you for those comments because as I read the report one of the main reasons why they were skeptical of Ares I was the station was scheduled to be de-orbited in 2015. The Ares I would come online 2015, 2017, by their estimates on the committee. So, okay, that makes sense if what we are using is going to be gone, but as you alluded to, bipartisan agreement that we need to go to 2020, and there are international partners interested in going beyond that.

INCREMENTAL TRANSITION TO COMMERCIAL

And then just one final question, and I just wanted to sort of address my good colleague, my friend from California. I just want to assure you that I am a supporter of commercial spaceflight, but we have got to do this incrementally, and they need to prove to us first that they can do the cargo mission, and I think they, you know, if they can do that cargo mission, that is a great first step. But as my colleague knows, there is a huge difference in flying cargo and flying human beings. Just the modifications to the vehicle, the redundant systems, the backup to the backup to the backup that are required because a human being, a man or a woman, is placed on that vehicle. It is a much different equation. I have had many meetings with the commercial contractors, and they are good people, they are very capable, and they are doing the American dream. I mean, they are out there developing, and the stuff that has made our country great, but they are not ready yet for human spaceflight. They are getting to the point where they are getting ready for commercial, but they are not ready for human yet, and that is my concern.

In talking to them, one of them in particular, one that you are very familiar with, said, you know, we are complying with NASA's requirements for human spaceflight, and we have had Admiral Dyer come here and testify to us a couple months ago who said no one can say that with a straight face in this world because NASA hasn't published the requirements for human spaceflight.

So just want to make sure for the record everybody knows that I am a supporter of commercial spaceflight, but it has got to be incremental. Cargo first and then human.

And I yield back my time. Thank you.

Ms. EDWARDS. Thank you, Mr. Olson. I would like to recognize at this time Mr. Hall.

Mr. HALL. Thank you. Mr. Cooke, and by the way, I am glad to see Mr. Young here, back here. I know some good days with Norm Augustine and the services of the two of you and others yielded to this Congress and to this country, and I thank you for your part of that.

PLANNING FOR TERMINATION

And I understand the question was asked of you if you had a plan to how you are going to shut down something. I don't how I would answer that. If I organize something, I don't think about it shutting down. Now, if you are going to fight a war, I would admit you need to have a way out if you are going to do that, you know, to have a plan for retreating if you have to, but in this I don't think you would think about shutting it down if you are going into it. Maybe I am just not thinking enough, but I started and finished several industries and never occurred to me that I could fail until I failed one time, and I never forgot that. You know, it is like in Vegas what you lose hurts you a lot more than what you win helps you.

But I understand your not wanting to make an answer to that question, but I guess you could think about it and give her a letter on it later if that would help.

TRANSITIONING CONSTELLATION INFRASTRUCTURE

I wanted to ask Mr. Cooke, the Shuttle Program is carrying a lot of the overhead costs associated with human spaceflight, and a lot of that agency overhead cost was planned to be assumed by the Constellation Program after the 2010.

Where will NASA—how will they account for that, for the overhead cost under the commercial crew program? And will the burden for maintaining America's human spaceflight capabilities be shifted to the emerging so-called commercial entity since they will clearly be beneficiaries of it?

Mr. COOKE. The transition of workforce, the transition of facilities and hardware has been something that we have worked between the Shuttle and the Constellation Program. We have had an active effort in that, so now we will be working a transition effort with some of what that content was as well as from Constellation. That is forward work. We do have a transition team that is working, building off of that experience to understand how we do work through those facilities and so on.

But we don't have an answer on what that will be yet. That is underway.

Mr. HALL. Whatever happens to NASA's existing launch infrastructure such as the launch pads or the processing facilities, the mission control center? What happens to those? Just shut them down?

Mr. COOKE. Sir, that is forward work, and certainly we will be—and it is not in my budget but in the Space Operations Mission Directorate budget to work the 21st Century Launch Program down at the Cape, but we will be working with industry, we will be working within NASA to understand the future of all of that capability and perhaps——

Mr. HALL. Do you think there will be some benefit to that?

Mr. COOKE. There could well be. Should be.

STATUS OF COMMERCIAL CARGO

Mr. HALL. Well, then what exactly is the purpose of the 312 million you are requesting for commercial cargo in FY 2011?

Mr. COOKE. That part of the budget is—we are working through the details with the companies that we have onboard now, which are Space X and Orbital Sciences, to understand how we can reduce some risks in their schedules by—with additional testing, potentially an additional flight test for one of them, developing, enhancing some of their capabilities to provide cargo to Space Station.

Mr. HALL. I thank you, and I yield back.

TERMINATION OF ORION CAPSULE

Ms. EDWARDS. Thank you, Mr. Hall. I would like to recognize Mr. Perlmutter, who is visiting with us today, for five minutes.

Mr. PERLMUTTER. Yeah. From far away. My name is Ed Perlmutter. I represent the suburbs of Denver, so we have a substantial facility, Lockheed manages and operates, that is building the Orion capsule, and this—I have to say that the decision by NASA to cancel the program, cancel the entire Constellation Program has sort of turned things upside down in Jefferson County. It has been a very solid project, seems to have been, you know, operating, you know, and passing all of the tests that NASA and the Augustine Committee have talked about.

So can you explain to me why Orion is a casualty in all of this, too, or am I mistaken?

Mr. COOKE. The exact decisions are something that I was not directly a part of. I made inputs during the Augustine Committee, during the fall with NASA management on possibilities and options given the Augustine deliberations, and so I had input into that process, but I was not a part of the final decisions. I can't speculate on that.

The—in terms of where we go from here in the budget request there is the commercial crew part of the budget that is $6 billion over the run-out, where these kind of capabilities certainly could be involved in that future through proposals.

Mr. PERLMUTTER. I guess where I am coming from, I think Mr. Olson, he and I are pretty much on the same wavelength with respect to the Constellation Project and its many features, but it is lots of jobs in my area, and they are great jobs and with good people.

And I know the space industry, Lockheed, Raytheon, General Dynamics, all of the, Northrop Grumman, it can be boom or bust in that business, but here is one where, you know, you get to the guts of the thing, which we—I believe in manned spaceflight. I believe

that it is sort of a component part of American science. It is about exploration, it is about, you know, our desire to be bigger than we are, to do things beyond our reach, and then you get down to the real particulars, and it is a lot of jobs.

So how does the program plan to deal, you know, as I am trying to build jobs in Jefferson County and in the seventh Congressional District, now I have got to deal with this hole. Is there any kind of way that NASA or anybody else is planning to backfill this stuff?

Mr. COOKE. I definitely understand your concern, and with the new programs that we have and the technology development and the commercial crew and in precursor missions that are in our budget to scout out some of the destinations that are possible with humans, as well as in flagship demonstrations and technology demonstrations, there will be opportunities to compete for those, and that is what is in our budget request.

Mr. PERLMUTTER. So you would then suggest that these folks could just move straight into the commercial side and really not have to be a project that is managed by NASA. It is just let Lockheed do it itself.

Mr. COOKE. That is a potential. In terms of how we do that.

CONTRACTOR RESPONSE

Mr. PERLMUTTER. But let me ask a question. In dealing with your contractors, do they want this? Does a—I mean, I haven't asked Lockheed. I don't know whether Northrop Grumman, I don't know whether some small company up in Boulder, Colorado, because I know there are companies in Colorado that are interested in the commercial side of this.

But this is so intensive in terms of the infrastructure and the cost that I don't know how any company can do it. I mean, maybe it is a rhetorical question. If you can respond, I would appreciate it.

Mr. COOKE. Well, certainly it is a shift in direction for exploration, and you know, what we will be doing is providing these competitions and those opportunities.

Mr. PERLMUTTER. Thank you, and I appreciate the committee allowing me to speak, and I yield back.

Ms. EDWARDS. Thank you. At this time I would like to recognize Mr. Rohrabacher for five minutes.

COMPOSITION OF FUTURE PANELS

Mr. ROHRABACHER. Well, thank you very much. I am sorry that the Chairman had to step out or Chairwoman had to step out because I would like to make a recommendation. This sounds like a very significant issue that is being discussed, and maybe it would be nice to have more than one person in the room who had the other side of the argument to present, and I would suggest to my colleagues that we might want to have an actual debate or presentation to the committee in which sides could actually make their points and discuss it openly and be on the record. It might be nice to have a little real honest debate among experts on this issue, and I do not pretend to be an expert. Mr. Young, you, of course, are a

much better expert at this than I am, as is Mr. Cooke, but I would suggest that to the committee.

GOVERNMENT INADEQUACY AT TECHNOLOGY DEVELOPMENT

To my colleague who just said, hey, I can't conceive, it is very hard to see how private sector can do these things, it is really impossible to consider how the private sector could build an airplane back early on in the last century, and what we did and the same way—it was almost impossible to conceive how we were going to have railroads and how they were going to provide transportation to the country. And the fact is the government did not do the job. That was left to the private sector in both airlines as well as in railroads. Otherwise it would have been ten times as costly.

Let us just note that the Ares Project was $9 billion and not one new piece of technology was developed for that $9 billion yet. That—when they took off, there was no new piece there that they said, the engines or anything else, that there was a brand new piece of technology. I went down to Space X, and they have invested about $300 million, and they have got brand new technology, and of course, they don't have as many PR men working for them, they don't have all the other government things that are guaranteed to companies that make things more expensive, but if the private sector can do something for half as much or even 1/5 as much as what the public sector can do, we are limiting what our accomplishments are going to be in space by insisting that the government or the bureaucracy is the only one who can really be trusted to get the job done.

I would note that we also—there was also a colleague suggested, well, this is like Blackwater. We can't contract with Blackwater. Well, we do contract with Blackwater for some important jobs, and they have done a good job, but let me note maybe the better comparison would be when our government contracts with a private airline to take our troops someplace. We are talking about setting up a space transportation system, just like we had a system of railroads and an airline system.

Would it be better to have the government run it and have an agency dominate all the decisions? No. No, it wouldn't have been, and I believe that is the same way and the same truth for what we are setting up now as a space transportation system. But we need the government to set standards as they do for aviation, et cetera, and help in developing technology as they do for aviation.

HUMAN RATING REQUIREMENTS

Mr. Cooke, how long will it be before NASA develops human rating requirements and qualifications and verifications for the process for—in terms of commercial crew? How long is that going to take NASA?

Mr. COOKE. We are working on that right now. We have a draft set of requirements and processes that we will be putting out at the end of April for comment by industry with responses back by the end of May, and we are due to vet those within the—within NASA and be complete with that process by the end of this fiscal year.

Mr. ROHRABACHER. Okay. So by the end of the year we are going to know what NASA believes are the actual prerequisites for human spaceflight and what requirements for various vehicles?

Mr. COOKE. That is our plan.

EFFICIENCY OF GOVERNMENT PLAN

Mr. ROHRABACHER. Okay, and Mr. Cooke, do you think that it would be more expensive to—of course, we don't know what those requirements are yet, the government part hasn't done their job yet to see what those requirements are, but once they do, do you think it will be more costly or less costly to proceed with having Delta and Atlas meet some of those qualifications and meet those requirements versus the $9 billion that we have already spent on Ares and Orion that hasn't gotten us anywhere?

Mr. COOKE. I really can't speculate until we do solicitations and get proposals.

Mr. ROHRABACHER. Okay. Well, see, Mr. Young should answer that, too.

Mr. YOUNG. If I could answer a couple of your questions if the Chair would allow.

I have got to go back—allow me. You mentioned airplanes, a good analogy. I am a big admirer of our airplane industry. Even today airplanes is a very mature industry. Airplanes land every day with problems that would be catastrophic in the human spaceflight program. Every day. They probably have done it while we have been having this hearing.

So I think the analogies, you know, are interesting but not directly applicable. If we come back to the requirements, and I think what Doug Cooke said of NASA levying the requirements for safety is a good thing to do, but I will remind all of us that the reason things fail today won't be in those requirements documents. In other words, the requirements will not say don't confuse English and metric units, which is the reason Mars '98 failed. It won't say don't write down the wrong number in the guidance equation for a Titan IV which is why a Titan IV failed. It won't say don't let the foam hit the leaning edge of the wing, and the only thing I really—the point I am really trying to make is the requirements, the safety requirements are important, and they should be done, but they won't get the job done. What will get the job done, repeat it again, is the strength of NASA and the incredible strength of industry, you know, working together to make these items happen.

You mentioned the EELV. Two comments. First off, the EELV started out as a commercial enterprise as you know as well as I do obviously.

Mr. ROHRABACHER. Yeah.

Mr. YOUNG. There were a large number of space system failures. I chaired a review for Lockheed Martin, Sheila Widnall chaired one for Boeing, looked into that, and Larry Welch chaired a Presidential Commission to look into the launch vehicles.

And out of that the Presidential Commission's basic conclusion was that EELV proceeding as a commercial system when the commercial market fell apart and didn't really happen, were following practices that were not consistent with the practices that we knew

were necessary to make these things have a sufficient and high probability of success.

So the EELV Program was changed, and it was changed to implement techniques that we have experience with that we know how to make these things work. So EELV is no longer, you know, really a commercial system, and your other comment about we could certainly take the EELV, and we could human rate it.

Mr. ROHRABACHER. Right.

Mr. YOUNG. Aerospace did a study. They said it would take between 5-1/2 and 7 years——

Mr. ROHRABACHER. Right.

Mr. YOUNG. —to do that. I must admit, I am kind of struck by it being that long to be honest, but that is what they said. They identified no basic cost advantage, and in addition to that what I know about it is that if you what you would like to do is to take your initial space transportation system that you went back and forth to Space Station, and you would like to be able to grow that to—and I am not working your economic equation. You would like to be able to grow that to a heavy-lift, you would like not to have two systems, and there is no question in my mind and Doug could certainly comment, no question in my mind you can grow something like an Ares I into a heavy-lift capability much more efficiently than you can grow an EELV into a heavy-lift capability.

And I think, again, if you go back and look at the details of that Aerospace study, you know, it will kind of support that.

So, again, the point I, you know, that you and I have really been discussing, and I always enjoy my discussions with you I should say——

Mr. ROHRABACHER. Thank you.

Mr. YOUNG. And by the way, it is a terrific example of what I am trying to say is I end up with better thoughts having debated with you, and I hope maybe you have debating me.

Mr. ROHRABACHER. Absolutely. Thank you.

Mr. YOUNG. And that is really what I am talking about is how NASA and industry works together.

Mr. ROHRABACHER. Yes, sir.

Ms. EDWARDS. Thank you, Mr. Young, and thank you, Mr. Rohrabacher.

TECHNOLOGY DEVELOPMENT IN CONSTELLATION

We are going to about draw to a close and because we are expecting votes shortly, but I want to just ask as we close here, Mr. Cooke, in reference to Mr. Rohrabacher's point, what new technologies has Constellation developed?

Mr. COOKE. In the Constellation Program we actually have some technologies we have been working that will be potentially migrated into our technology programs. Automated rendezvous and docking is one that we are working on the Orion. In the upper stage we are making further progress on the technology of friction stir welding. We are working composite structures. We have made some advances in lightening protection on space vehicles, advanced batteries. We are using advanced solar arrays on the spacecraft. We are making advances in guidance, navigation, and control and other avionic software that will be possible.

We have actually in an advanced development work out at Ames we have developed technology in thermal protection system, advanced thermal protection systems for spacecraft. We are working in closed life support, and we have—we are actually charting some new territory in modeling of the environments and characteristics of the spacecraft during launch and entry through new modeling techniques and software.

Ms. EDWARDS. Thank you. I mean, as you described a number of new technologies developed in that little government-supported program.

Mr. Cooke, just as we do close, by the end of the authorization and appropriations process I hope that we and the Administration can craft a productive path forward for NASA's human spaceflight program, and given the concerns expressed by members both on and off the committee over the suitability and sustainability of the proposed redirection, we are going to be looking at this investment that we have already made in the Constellation Program, significant investment to see whether it and how it can be part of the solution.

CONSTELLATION PDR

And in that regard, I mean, you have just completed the Constellation Program's PDR. What is the status of Constellation? Does it have any fundamental problems, or is it on track technically, and just a yes or no answer would be good for that.

Mr. COOKE. Just briefly, the Board for the preliminary design review did recommend its advance toward critical design review, which, I mean, we are working issues as all programs do, but they are being worked.

Ms. EDWARDS. And is there—on the commercial side are they anywhere near that?

Mr. COOKE. Well, at this point we are not developing the commercial crew yet, and that is what this new program is for.

Ms. EDWARDS. Exactly. Thank you, and just finally, though, you know, I hope that part of what you have heard here today is that we don't believe, many of us on this committee don't believe that the—that NASA either has the authority or either through appropriations or authorization to terminate programs at this stage. This is a work in progress, and so I hope you will go back to your superiors and urge them to rethink any approach in dealing with Constellation during the remainder of the fiscal year that might impact it and the full program for the future given that we haven't closed out the conversation yet. This is of deep concern to many Members of the Committee. It is a concern that I have as we have heard it over and over again, both in terms of the impact on the workforce but also the impact on the program given that Congress hasn't weighed in yet on the President's budget proposal.

I want to thank our witnesses for testifying before the subcommittee today. The record will remain open for two weeks for additional statements from members and for answers to any follow-up questions the subcommittee may ask witnesses, and the witnesses are excused, and the hearing is now adjourned.

Thank you very much.

[Whereupon, at 4:45 p.m., the Subcommittee was adjourned.]

Appendix 1:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. Douglas Cooke, Associate Administrator, Exploration Systems Mission Directorate, National Aeronautics and Space Administration

Questions submitted by Chairwoman Gabrielle Giffords

Q1. NASA's FY 2011 budget request states that commercial human spaceflight services "will ultimately open space travel to many more people across the globe." Yet a 2002 market study on space tourism that the administration used in support of its decision to fund the development of a commercial crew transport industry concluded that a private citizen would have to have a net worth of at least $200 million to afford a ticket for commercial orbital space travel under current ticket price projections.

a. Is this small percentage of the world's wealthiest people the population that NASA is aiming to support as it funds the development of this commercial crew transport industry?

b. If so, given current budgetary constraints, why does NASA consider that to be the best use of scarce taxpayer dollars?

A1a, 1b. NASA is not aiming to support any specific population. The vision of commercial human spaceflight to Low Earth Orbit (LEO) is a robust, vibrant, profit-making commercial enterprise with many providers and a wide range of private and public users. NASA hopes to develop a framework for this initiative that accommodates a diversity of people (e.g., astronauts, international partner personnel, scientists, spaceflight participants) for a variety of reasons (e.g., science, research, station operations, tourism).

NASA's FY 2011 budget request for commercial crew will help develop a critical capability that is needed by the Agency. NASA's primary objective is to invest in commercial access to space and take advantage of it for transportation of U.S. astronauts to and from the International Space Station. By investing in commercial crew efforts over the next five years, NASA can focus on the forward-leaning work we need to accomplish for beyond-LEO missions. Additionally, this investment will:

- Reduce the risk of relying solely on Russia to transport astronauts to the ISS following the retirement of the Space Shuttle;
- Free up NASA resources to focus on the difficult challenges in technology development, scientific discovery, and exploration;
- Make space travel more accessible and more affordable.
- Build an enhanced U.S. commercial space industry that creates new high-tech jobs, leverages private sector capabilities, spawns other businesses and commercial opportunities, and spurs growth in our Nation's economy.
- Inspire a new generation of Americans by these commercial ventures and the opportunities they will provide for additional visits to space.

Q2. In light of continuing accounts regarding other countries' plans to undertake human lunar exploration missions in the future, how adaptable is the administration's approach, which would result in the elimination of all ongoing human spaceflight vehicle development programs, to a shift in the geopolitical landscape and subsequent renewal of interest in a U.S. Moon landing? For example, would it allow us, if necessary, to accelerate development and recover in time to perform a lunar landing in the early 2020s?

A2. The Administration developed the FY 2011 budget request based on what it believes is the best long-term strategy for human space exploration; it did not develop the budget based on an estimate of the geopolitical landscape now or in the future. For its part, NASA looks forward to implementing whatever policy direction is given to us, now or in the future. NASA is capable of accelerating work on the vehicles required to reach the lunar surface if that became a national priority and adequate funding were to be appropriated.

Q3. A January 2010 article in Spaceflightnow.com quoted the NASA Administrator as saying "Whether it be future human voyages beyond low Earth orbit, or complex sample return missions from Mars and deep space objects, or building future large space telescopes, NASA must pursue a new era of international cooperation, a relationship where partners are treated as equals."

a. What is the U.S. strategy for international engagement in the human spaceflight activities and exploration beyond low-Earth orbit proposed in the FY 2011 budget?

A3a. NASA initiated a multilateral dialogue with thirteen international space agencies in 2006 that resulted in the May 2007 release of the "Global Exploration Strategy—The Framework for Coordination." The GES "Framework Document" articulated common themes and a shared vision of globally coordinated human and robotic space exploration. The Framework Document also recognized the need to establish a voluntary, non-binding international coordination mechanism through which individual agencies may coordinate their respective exploration interests. The International Space Exploration Coordination Group (ISECG) was established in late 2007 for this purpose. In addition to this very effective multilateral approach, NASA anticipates continuing to build both on its established as well as emerging bilateral relationships. Consistent with the U.S. Space Policy, the President's proposed budget affords increased opportunities for NASA to serve as a global leader and to establish early, critical cooperative opportunities with our international partners.

Q3b. How will we cooperate with our international partners and engage other nations in human exploration if we are uncertain about what we will be doing and what the architecture will be?

A3b. The GES Framework Document recognizes that each participating agency will maintain the flexibility to pursue its national exploration interests, yet the ISECG provides a forum for agencies to identify common interests from which meaningful cooperation could be achieved. The GES framework process was designed to be flexible and to adapt to changing circumstances and national priorities. In creating the framework document and the ISECG, significant progress was achieved in learning how to coordinate common exploration goals and architectures that respond to those goals. NASA anticipates utilizing these processes to develop global architectures for destinations in addition to the Moon, including Near Earth Objects and Mars.

Q3c. If we are seeking to maintain our international leadership in human space exploration, what is it we bring to the table?

A3c. Consistent with the more than 50 years of NASA leadership in human spaceflight, the proposed 2011 budget makes significant investments in a number of areas which are of great interest to our international partners:

- Extension and increased utilization of the International Space Station to test and demonstrate key enabling technologies and capabilities vital to further exploration;
- Transformative technology development and flagship technology demonstrations to pursue new approaches to space exploration;
- Robotic precursor missions to multiple destinations in the solar system;
- Research and development on heavy-lift and propulsion technologies;
- Education and Participatory Exploration, including focus on STEM.

The level of proposed investments is substantial and serves as a catalyst for cooperation and its significance, compared to the investments being made by our international partners, sets a strong tone of leadership within a context of cooperation. Accordingly, NASA has already received significant interest in these areas from our partners. We are currently working with them to define our common long-term exploration interests, as well as near-term cooperative activities in several areas of the proposed 2011 budget. In particular, precursor robotic missions may be a fruitful area for near-term collaboration with other nations.

Q3d. Under the proposed FY 2011 budget plan, the U.S. government wouldn't be able to offer a launch vehicle, a crew exploration vehicle, or a lunar lander. How influential could this country expect to be in the international space community without such assets?

A3d. The FY 2011 budget request provides NASA with significant influence in the international space community because it opens and enables many more opportunities for international collaboration and partnerships. Under the previous plan, much of our program was off limits to international participation, including important roles on critical elements. As a result, there was some discontent among the international community and there were fewer options for significant strategic partnerships that could substantially increase the affordability and sustainability of the program. The 2011 budget request positions NASA to be the global space technology leader and invites international partners to participate in the development of transformational new technologies in areas such as heavy lift and in-space propulsion, flagship technology. At the same time, the new plans create a more robust industrial and technical base from which to leverage the new capabilities in key mission systems that will open greater opportunities for human space exploration. The net

result could be substantially greater and more robust international participation and cooperation to allow more challenging missions sooner, all of which is consistent with our new U.S. Space Policy and national objectives, and precursor robotics missions to multiple destinations in the solar system.

Questions submitted by Representative Pete Olson

Q1. What is the requirements rationale for attempting to develop a high-energy engine for Orbital's Taurus II upper stage?

A1. A high-energy engine for Orbital's Taurus II upper stage has always been part of Orbital's development plan for Taurus II. In fact, the third mission under the CRS contract incorporates greater cargo carrying capability of the Taurus II provided by a high-energy upper stage. The plan and proposal was negotiated with Orbital as part of Federal Acquisition Regulations part 12 fixed price procurement.

Q1a. What is the expected cost to the Government to proceed with that development?

A1a. If NASA includes a high-energy upper stage for the Taurus II as part of its COTS Cargo augmentation items to support multiple missions including non-CRS uses, then NASA would only fund a portion of the upper stage development costs. This is consistent with the COTS Cargo Program philosophy of the commercial partner also providing capital. While NASA has not negotiated its share of the development costs, it is anticipated that NASA may contribute approximately $30M–$35M for this development effort, if deemed appropriate.

Q1b. If Congress does not appropriate money to pursue this work will Orbital Sciences be unable to fulfill any of its existing commitments under the CRS contact?

A1b. The $312M in the NASA FY 2011 budget request for commercial cargo is for incentivizing current commercial cargo providers to improve the chance of mission success by adding or accelerating the achievement of already-planned milestones, adding additional capabilities, or adding tests that may ultimately expedite the pace of development of cargo flights to the ISS. However, whether or not the funds are appropriated and used in this manner, OSC is legally required to meet its milestones and deliver services under the terms of the CRS agreement.

Q2. What is the requirements rationale for attempting to develop a Block 2 engine upgrade for SpaceX's Falcon 9?

A2. The Block 2 engine upgrade for SpaceX's Falcon 9 would reduce the cost associated with the Falcon 9 first stage and provide engine commonality with the Falcon 1e. This commonality would increase the engine's overall production and flight rate, further reducing cost and potentially increasing the engine's reliability. While NASA is confident in SpaceX's ability to develop a Block 2 engine upgrade for the Falcon 9, this development activity does carry risk.

With the Administration's decision to extend the life and enhance the utilization of the ISS, cargo transportation services are more critically important to NASA. Thus, providing an investment to assist with the development of a Block 2 engine upgrade for the Falcon 9 reduces the risk associated with the development of this planned capability, potentially reduces NASA costs for cargo transportation services, and potentially increases the reliability of the Falcon 9 cargo transportation flights to the ISS.

Q2a. What is the expected cost to the Government to proceed with that development?

A2a. NASA has not negotiated its share of the development costs associated with the Falcon 9 Block 2 upgrade. Thus, exact costs to the Government are not known at this time. However, as an estimate, NASA may contribute approximately $40M–$45M for this development effort.

Q2b. If Congress does not appropriate money to pursue this work, will SpaceX be unable to fulfill any of its existing commitments under the CRS contract?

A2b. Whether or not funds are appropriated and used to develop a Block II upgrade for Falcon-9, SpaceX is legally required to meet their milestones and deliver services under the terms of the CRS agreements.

Q3. What changes to the existing CRS contract milestones and/or schedule would be necessary if Congress does not appropriate the $312 million requested for commercial cargo in the FY 2011 budget?

A3. No changes would be necessary because the CRS contract/schedule would remain the same should the additional funding not be appropriated. However, there is greater risk to NASA and the ISS Program.

Q4. If Congress does not appropriate the $312M requested in the FY 2011 budget for commercial cargo, how will that impact SpaceX's ability to successfully fulfill its CRS contract obligations?

a. Which milestones would not be performed?

A4a. Whether or not the $312 million requested in the FY 2011 budget for commercial cargo is appropriated, SpaceX is legally required to meet all of its currently negotiated milestones and deliver services under the terms of the CRS contracts.

Q5. If Congress does not appropriate the $312 million requested in the FY2011 budget for commercial cargo, how will that impact Orbital Sciences ability to successfully fulfill its CRS contract obligations?

a. Which milestones would not be performed?

A5a. Whether or not the $312 million requested in the FY 2011 budget for commercial cargo is appropriated, Orbital Sciences is legally required to meet its currently negotiated milestones and deliver services under the terms of the CRS agreements.

Q6. What is the underlying requirements rationale for proposing to initiate development of a first stage hydrocarbon engine?

a. What requirements would be satisfied that cannot be satisfied with solid rocket motors?

A6. The underlying requirements rationale for proposing to initiate development of a first stage hydrocarbon engine is lower development and operations costs, with the potential that NASA may not be the only user of the engine. When NASA is the only user of a rocket, NASA alone must support the industrial base required to build that rocket, which can greatly add to the cost of a vehicle.

NASA plans to continue heavy lift launch vehicle studies in partnership with the Department of Defense (DOD) to continue to mature the LOX/Hydrocarbon concepts and to assess potential commonality between NASA, DOD, and potential commercial needs with the primary figure of merit as affordability and operability. The underlying requirements rationale for proposing to initiate development of a first stage hydrocarbon engine is lower development and operations costs. However the trade studies outlined above will confirm this assertion.

Q7. What is the requirements rationale for the proposed LOX/CH4 engine development?

a. What has changed since the ESAS decision not *to pursue the development of such an engine?*

A7a. As part of the FY 2011 President's budget request, NASA will initiate development and engine testing with a focus that could include a low cost, high performance "green" liquid oxygen/methane (LOX/CH4) engine and potentially also low-cost liquid oxygen/liquid hydrogen (LOX/LH2) engines. This work builds from NASA's recent R&D experience in this area, using existing test articles and results to develop a re-startable engine capable of high acceleration and reliability.

One of the options for the in-space engine is a LOX/Methane engine. The objective of this LOX/Methane development effort is the demonstration of key operational performance characteristics of a range of new space engines, compatible with future use of *in situ* resources that can eventually lead to the development of a low cost, high performance "green" service stage to be used with in-orbit fuel stations, with

large payload and crewed vehicles or as an In-Situ Resource utilization (ISRU)-compatible planetary ascent stage.

During ESAS, the choice of LOX/Methane instead of hypergolic fuels for the Service Module and Lander ascent engines was made and was supported by several factors such as a higher performance engine with a lower overall system mass as well as ground operations at the launch site should be simpler. In addition, a more compelling factor was that LOX/Methane opened up the possibility using In-situ Resource Utilization (ISRU) techniques of using Martian resources for fuel. The Constellation program moved away from LOX/Methane due to development risk impeding the schedule as well as available budget resources.

Q8. According to NASA's testimony, the marginal cost of an operational Ares 1 based on two flights per year would be about $176 million per flight and have the capability to carry approximately 5 metric tons of cargo to the ISS orbit. This implies a cost to ISS of about $35,200 per kg. *NASA's initial CRS contracts (prior to the FY 2011 budget request) totaled $3.5 Billion to deliver a total of approximately 40 metric tons to the ISS. This implies a cost to ISS of about* $87,500 per kg. *In order to resolve this huge discrepancy and provide NASA's justification for pursuing a policy that is so costly to the American taxpayer, please provide the following:*

a. The fully-burdened cost estimate per flight, and the fixed and marginal cost per flight, of the Ares 1/Orion. Please provide these estimates for flight rates between one and six flights per year.

A8a. NASA does not have a full burdened cost-estimate per flight because NASA does not commit to development estimates prior to completion of Key Decision Point C, where the project transitions from Formulation phase (A/B) to Development phase (C/D). Ares I has not completed KDP–C.)

With regard to the fixed and marginal costs, 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, EVA 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 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.

Q8b. The fully-burdened cost estimate per flight, and the fixed and marginal cost per flight, of the SpaceX Falcon 9/Dragon. Please provide these estimates for flight rates between one and six flights per year.

A8b. Specific launch cost data for Falcon-9/Dragon and Taurus II/Cygnus are considered procurement and competition sensitive, and their provision would compromise the commercial environment for these launch activities. We respectfully recommend that you contact Space Exploration Technologies and Orbital Sciences Corporation regarding this information.

Q8c. The fully-burdened cost estimate per flight, and the fixed and marginal cost per flight, of the Orbital Sciences Taurus II/Cygnus. Please provide these estimates for flight rates between one and six flights per year.

A8c. Specific launch cost data for Falcon-9/Dragon and Taurus II/Cygnus are considered procurement and competition sensitive, and their provision would compromise the commercial environment for these launch activities. We respectfully recommend that you contact Space Exploration Technologies and Orbital Sciences Corporation regarding this information.

Q9. NASA's budget request states that, "some amount of private investment capital" will be part of any Space Act Agreement.

a. Does NASA intend to solicit any evaluations from outside financial analysts before issuing new Space Act Agreements?

A9a. NASA ensures that any selection criteria associated with competitive awards are appropriately evaluated. To the extent NASA determines that it does not have the appropriate expertise resident within the Agency to evaluate any aspect of a competitive award, NASA has the ability to engage outside experts prior to making awards. This will be decided as NASA develops and finalizes its acquisition strategy.

Q9b. Has NASA determined what level of private investment will be required to supplement the federal government's commitment?

A9b. Currently, NASA intends to ask proposers to specify the level of private investment they have available to support their development efforts if selected to receive NASA funding.

Q9c. Is there a minimum threshold, or will NASA simply enter into agreements with entities offering the best price without specifying a minimum percentage or a minimum amount of private capitalization?

A9c. NASA does not currently intend to prescribe the level of company investment required to supplement the federal funding commitment. Similarly, NASA does not expect any company to be in a position to propose a "price" for the commercial space transportation "services phase" as an element of its proposal to participate in NASA's commercial crew transportation development effort. The level of investment will be assessed as part of the overall business plan and will be a risk-based consideration in the portfolio of companies selected for award. This will be decided as NASA develops and finalizes its acquisition strategy.

Q9d. What criteria will NASA use to evaluate whether an entity has the appropriate level of private capitalization?

A9d. NASA is still finalizing a strategy to support the development commercial crew transportation services so that the Agency is prepared to proceed if funding is provided in the final FY 2011 budget. Selection evaluation criteria will be established as NASA develops and finalizes its commercial crew acquisition strategy.

NASA plans to evaluate the business plans, including financing and sources of funds, as part of the overall portfolio selection. The amount of private capitalization is just one of several factors planned to be evaluated.

Q9e. What penalties will NASA incorporate in Space Act Agreements to protect the government in the event of non-performance by the commercial entities?

A9e. NASA is still finalizing a strategy to support the development commercial crew transportation services so that the Agency is prepared to proceed with competitive awards if funding is provided in the final FY 2011 budget. NASA will ensure that the taxpayer interests are protected.

Q9f. What organization within NASA will be responsible for evaluating the satisfactory amount of private investment capital?

A9f. A NASA source evaluation board or equivalent will review the proposed business and financial plans, and the source selection authority will determine how much Government funding to award the winner(s) and how much Government funding should be allocated among awardees. It is expected that this source evaluation board will be established by the Exploration Systems Mission Directorate.

Q10. Developing the human rating requirements for the Ares/Orion system was the product of a long process of negotiations between ESMD and OSMA.

a. Under the commercial crew proposal, how long does NASA estimate it will take to produce new human rating requirements, and once that step is completed, what will be the process to ensure the U.S. Government has the necessary insight and oversight to determine whether vehicles and systems comply with the standards?

A10a. NASA is still finalizing a strategy to support the development of commercial crew transportation services. Such a strategy will include planning for applicable technical requirements, certification process and the role of the Government versus the industry partners in terms of insight, oversight and potential Government-furnished equipment. Also, on May 21, 2010, NASA issued a Request for Information (RFI) seeking information that will help NASA formulate plans for Commercial Crew Transportation (CCT) as proposed in the FY 2011 budget request. The purpose of this RFI is to collect information from industry to help NASA plan the overall strategy for the development and demonstration of a CCT capability and to receive

comments on NASA human-rating technical requirements that have been drafted as part of this initiative. Responses to the RFI and the accompanying draft human rating document were due to the Agency on June 11, 2010. NASA hopes to finalize the human rating document by the end of the calendar year.

Q10b. Will it be an iterative process similar to what occurred with Ares/Orion?

A10b. The development of commercial human rating requirements has been an iterative process with NASA safety, engineering, and health and medical technical authority participation, among others. NASA will continue the iterative process via the aforementioned RFI soliciting comments from industry.

Q10c. Once the commercial human rating requirements are published by NASA, what is your estimate of how long it will take for a commercial crew provider to build, certify and flight test its launch system?

A10c. Based on the President's FY 2011 budget request for commercial crew development, NASA is currently planning for the demonstration phase to be complete in 2015 with actual missions starting in late 2015 or early 2016. As way of comparison, the Review of U.S. Human Spaceflight Plans Committee estimated that a commercial crew launch service could be in place by 2016. This estimate was based on estimates from providers ranging from three years to five years from the present, and an assumption for one year of program realignment with a start in early FY 2011.

Actual proposals from industry, however, will supply the best estimate, once they are available.

Q10d. What is the basis of that estimate?

A10d. When developing schedule estimates, NASA reviewed previous proposals received from industry in response to past COTS cargo solicitations—solicitations that also offered bidders to offer proposals for commercial crew capabilities.

Q10e. If there is no estimate, how was the budget derived?

A10e. Budget formulation documents and discussions are of a pre-decisional nature and thus cannot be provided.

Q11. Since the two COTS companies are significantly behind their schedules, why hasn't NASA re-competed the COTS cargo contracts?

a. At what point would NASA deem the contractor's performance unacceptable and re-compete?

A11a. Both commercial cargo development partners continue to make steady progress in achieving their cargo demonstration milestones. While each has experienced some milestone delays, this is not unexpected, since both partners have aggressive, success-oriented schedules, and are facing challenges typical of a spaceflight development program. As such, NASA sees no reason to doubt either company's ability to achieve its desired objectives—that of demonstrating commercial cargo delivery to and from the International Space Station in the 2011 timeframe.

NASA will not pay for a milestone until it is achieved. However, we reserve the right to continue working with a partner if we deem it is in the Government's best interest and that they are continuing to make acceptable progress toward their demonstration goals. NASA has invested significantly in the success of these cargo demonstration efforts and we are depending on both partners to develop commercial cargo services for delivery to/from the ISS. We want to help them succeed and we need for them to succeed. NASA consistently reviews each company's progress, and if their progress was deemed unacceptable, we reserve the option to terminate the agreement and to seek alternate partners. We would do so at the point when a partner stops making technical progress developing their system and assessments indicate the partner cannot be expected to complete the milestones in the agreement within a reasonable time period. This criterion was used when RpK, one of NASA's original COTS partners, was terminated when it ceased progress on its technical milestones as a result of the failure to meet its negotiated financial milestones.

Q12. 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?

A12a. NASA will endeavor to develop revised cost estimates as the Administration works with Congress to determine how Orion should be restructured, consistent

with direction outlined in the NASA Authorization Act of 2010 and the final FY 2011 appropriations for the Agency.

Q12b. Where in the budget will the funding come from?

A12b. The funding for this restructuring will come within NASA's top-line request released in February, consistent with direction outlined in the NASA Authorization Act of 2010 and the final FY 2011 appropriations for the Agency. The out year funding profile will be refined as part of the President's FY 2012 budget submission.

Q12c. What previous programs will be displaced by this new change?

A12c. The Administration and Congress will continue to work to develop a plan that balances a restructured Orion project with the other priorities in NASA's FY 2011 budget, consistent with direction outlined in the NASA Authorization Act of 2010 and the final FY 2011 appropriations for the Agency.

Q12d. How would such a vehicle get to the International Space Station?

A12d. An Orion crew emergency return module could launch un-crewed as a payload on a yet-to-be determined expendable launch vehicle, and then utilize autonomous rendezvous and docking technology similar to the European Space Agency's Automated Transfer Vehicle and Russian Progress spacecraft, or autonomous rendezvous with Remote Manipulator System capture/berthing such as the Japanese HII Transfer Vehicle and as planned for the COTS cargo vehicles.

Q12e. 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?

A12e. An Orion-based crew lifeboat would enable 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 would also help establish a technological foundation for future exploration spacecraft needed for human missions beyond low Earth orbit and will preserve some critical high-tech contractor jobs in Colorado, Texas, and Florida.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. A. Thomas Young, Lockheed Martin (Ret.)

Questions submitted by Chairwoman Gabrielle Giffords

Q1. In your prepared statement, you state that "A detailed exploration plan with destinations, dates and implementation plans is needed." What, in your view, is involved in developing such a good plan?

a. What can be held up as a model?

b. What would you recommend Congress do in the absence of such a plan from NASA?

A1. There are many examples of NASA programs with excellent plans. Apollo and the Mars robotic programs are two superb models. Most successful programs are characterized by detailed plans that focus the efforts of diverse organizations required to work together to accomplish a defined objective. A primary responsibility of leadership is to establish a detailed implementation plan with all the definition needed to provide program direction. Destinations, dates, etc. and required elements of the plan.

Failure to provide a detailed implementation plan is a failure of leadership and will result in a failed or highly inefficient program.

A budget without a detailed implement plan is an oxymoron. Congress should refuse to approve a budget without first having and approving a detailed implementation plan.

Q2. As a seasoned aerospace professional who has led and overseen the development of many complex, expensive military and civilian spacecraft, what, from your perspective, are the most significant challenges in implementing NASA's proposed plan for purchasing commercial crew services for access to low-Earth orbit?

a. Does the administration's estimated price tag of $6 billion and estimated 5-year time horizon to establish commercial crew capabilities across multiple commercial providers make sense?

b. What further information would you want to see in order to develop confidence in the proposed timeline and budget for this type of development project?

A2. Space projects are hard. Even with the application of our best capabilities all are not successful. We have developed a methodology that maximizes the probability of success. This methodology utilizes NASA's extraordinary leadership and continuity of human spaceflight expertise and the implementation capability of industry which is second to none. This partnership is a model that is tested, proven and continuously improved. Why would anyone make a drastic, unproven change to this methodology? Risk of such a change are enormous and involve mission, schedule, cost, workforce and space program risks.

I do not believe the $6B cost or 5 year schedule are realistic or supported by experience. I have seen no analysis that support these budget and schedule numbers.

I would not approve commercial crew without extensive proof of capabilities with flight performance. Commercial cargo can be a first step followed by non-NASA commercial crew demonstrations. I do not believe this can be accomplished on a schedule that will allow repetitive commercial crew flights to space stations prior to 2020.

Q3. The FY2011 request proposes $3.1 billion over five years for research in heavy-lift and propulsion technology. One of the areas this budget line is to emphasize is development of a first stage engine, and in particular, a hydrocarbon engine that would be used for a future heavy-lift vehicle. The congressional budget justification also indicates the projected level of funding is anticipated to lead to an operational engine by the end of the decade.

a. How important is the development of a new first stage engine, and in particular a hydrocarbon engine to development of a future heavy-lift vehicle?

b. Does the proposed budget and timeline make sense, in your view?

A3. The budget and timeline do not make sense to me. I am a strong supporter of technology development and I believe a human spaceflight technology program with mission focus is needed. However, I believe we have the capability to start heavy-lift today. Heavy-lift is dependent upon funding authority not a 5 year technology program. The $3.1B would be better utilized to start the heavy-lift development.

Q4. How will the absence of a specific exploration goal, timeline, and mission affect the advanced technology programs that the Administration is proposing?

a. Are there any lessons learned from previous technology programs that Congress should consider?

b. In your statement, you noted that "NASA, with appropriate outside support, should define the required technology program." What type of outside support would be involved and from what institutions?

A4. A technology program without mission focus often results in an inefficient, "hobby shop" approach. The technology developed in such an environment results in technology that satisfies the technologist but not the mission need.

The Mars robotic program has been a highly effective and focused technology endeavor. Rover, atmospheric entry, landing, electronics, etc., technology development have all supported a highly successful program.

I believe the best source of outside support is the National Academies. The Academies National Research Council (NRC) has the capability to make available extraordinary individuals to conduct reviews of NASA's technology program. Emphasis should be given to individuals with space project experience to assure the focus factor is not lost. I should note, I am a member of the National Academy of Engineering and the NRC Space Studies Board.

Appendix 2:

Additional Material for the Record

LETTER TO THE HONORABLE GABRIELLE GIFFORDS FROM GARY P. PULLIAM, VICE PRESIDENT, THE AEROSPACE CORPORATION

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March 19, 2010

The Honorable Gabrielle Giffords
Chairwoman
Subcommittee on Space and Aeronautics
Committee on Science and Technology
2320 Rayburn House Office Building
Washington, DC 20515

Dear Madam Chairwoman,

The Aerospace Corporation is pleased to submit responses to questions from the Committee on Science and Technology regarding our support to the Review of U.S. Human Space Flight Plans Committee (the Committee.)

Your letter requested responses related to our analyses performed in support of the Committee, and we have answered in that context. In several areas of questioning, the Committee did not task Aerospace. In some areas, Aerospace has previously performed related studies or analyses for NASA. We are always available to discuss these studies with the committee if desired.

The Committee hired Aerospace to provide technical analyses as directed. We were participants in committee activities only when receiving tasks, discussing ongoing analyses and delivering our products to the Committee. We acknowledge that the Committee received information not known to Aerospace.

Several questions inquire about dates, schedules and costs, and specifically which Committee member directed Aerospace in these matters. The Committee designated Mr. Bo Bejmuk and Dr. Ed Crawley as the two liaisons between the Committee and Aerospace. All tasking was received and executed within this framework. We respond in more detail to specific questions in our responses.

We respectfully submit our responses to the committee. We stand ready to assist the committee in any way possible as you work toward developing the way ahead for NASA.

Sincerely,

Gary P. Pulliam

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Responses to
The Committee on Science and Technology
Provided by
The Aerospace Corporation
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Question 1. The report of the Review of U.S. Human Spaceflight Plans Committee ["Augustine report"] states on page 70 that the Committee estimated that the design, development, test, and evaluation (DDT&E) cost to NASA is $3 billion for a program involving two commercial crew competitors and a NASA-provided "suitable version of an existing booster with a demonstrated track record of successful flight." It then goes on to say that "After multiplying by the historical growth factors and other multipliers associated with 65 percent confidence estimating (as will be discussed in Section 6.3), the cost carried in the Committee's final estimate of the cost of the program to NASA is about $5 billion"

a. The validity of the Committee's "final estimate" of $5 billion for commercial crew that was developed by applying historical growth factors and other multipliers to the $3 billion estimate is clearly greatly dependent on the reasonableness of the underlying $3 billion cost estimate to which the correction factors are applied. What was the source of the $3 billion estimate? Did it include all ground support/infrastructure costs? Did Aerospace independently develop or examine the basis for the $3 billion initial estimate for two commercial crew competitors and "suitable version of an existing booster with a demonstrated track record of successful flight"? If not, from where did Aerospace get the cost estimate? If it was from the Augustine panel, who on the panel directed Aerospace to use the $3 billion cost estimate in its subsequent analyses?

The Aerospace Corporation ("Aerospace") realizes there is considerable discussion around the "$3 billion" figure for a commercial transport capability, and we appreciate you inquiring about our role and perspective. As stated in the question, the Review of U.S. Spaceflight Plans Committee ("the Committee") stated on page 70 their assumption that "NASA should make available to bidders a suitable version of an existing booster with a demonstrated track record of successful flight, adding to the program cost."

Importantly, the Committee also stated on page 70 "The Committee then estimated the cost to NASA of creating an incentive for industry to develop the commercial crew transport capability for crew. This would probably be a significant fraction, but not the entirety of the cost of such a development."

This is the guidance the Committee gave to Aerospace: $3 billion would be carried in our affordability analyses as NASA's portion of the development. Aerospace did not independently develop the basis for the $3B initial estimate. The Committee did not ask Aerospace to independently verify the $3 billion figure. In fact, no verification could be performed given the Committee's statement that this dollar amount was simply NASA's portion of the total cost. Our role, as explicitly outlined in our task statement, was in some cases to develop our own estimates for certain elements where we were asked and qualified to perform the estimate, and in other cases to accept numbers from the Committee itself and/or the NASA analysis team. No traditional independent cost or independent schedule estimates were performed. Aerospace was not privy to all of the background material on the cost of commercially provided services which was provided in closed fact finding sessions to the Committee. In each case, we would seek to understand what was included in the estimate to assure there were no gross omissions or "double booking" and to uniformly apply historical cost growth factors to the NASA portions.

Specifically, the Committee's direction to Aerospace was that the $3 billion figure would include development of the capsule and launch abort system. An additional $400M, including $200M

(FY09) for a demonstrator flight and $200M (FY09) was allocated for minor modifications and integration to an existing launch vehicle with a demonstrated record of successful flight.

To our knowledge, this $3B estimate did not include all ground support/infrastructure costs. However, it was acknowledged by the Committee that these costs would be contractor/concept specific, and might be covered by other budget wedges present within a given integrated option affordability analysis. Also, facilities might be modified or made available to commercial contractors as part of a transition budget line, and then amortized across some number of flights during commercial operation. After including the $400M described above for a total estimate of $3.4M, Aerospace applied historical cost growth in the same manner as applied to other NASA developments. The Committee's final estimate of the cost of the program to NASA was approximately $5 billion. It was assumed that additional private investment funding would be required to complete the DDT&E.

As Aerospace developed and refined our affordability analyses of various Committee options, the Committee formed a working group of four members: Dr. Crawley, Dr. Ride, Mr. Bejmuk and Mr. Greason. This working group performed fact finding which provided specific assumptions and ground rules for our affordability analyses. Direction to use the $3 billion figure came to us from Dr. Crawley, who was the lead for the working group; however, the figure was consistently reiterated by all members of the working group when Aerospace interacted with them during the course of our analyses.

b. The Augustine report states on page 71 that "The Committee considered other factors that would support this estimate of the incentive cost to NASA. If this is to be a commercial venture, at least some commercial capital must be at risk. Alternate sources of capital, including private and corporate investment, would be expected." What was the percentage of the commercial crew development cost that was assumed to be paid for with non-government funds? Did Aerospace independently determine or validate that percentage? If not, what was the source of the percentage, and what is Aerospace's level of confidence in that percentage estimate?

The Committee assumed alternate sources of capital would be expected for the commercial crew development. While we engaged in detailed discussions about the $3 billion figure to be included in our affordability analyses, we did not receive any information about the Committee's view of the percentage required from alternate sources. It is possible the Committee received inputs from other sources not involving Aerospace's analyses. Aerospace is currently performing a business case analysis to address this key issue; however, that work is not yet complete.

c. Has Aerospace done any analyses to try to estimate the DDT&E cost of a commercial crew transport system? If so, what is the range of costs that Aerospace has come up with at the 65% confidence level for one or more such systems?

Aerospace has not performed a thorough, independent analysis to estimate the DDT&E cost of a commercial crew transport system. Aerospace did perform a comparison of the Committee cost estimate for the commercial crew system to historical programs as a cross-check on the existence of such a system in this cost range. The figure below shows actual and estimated development cost as a function of crew size for a range of capsule-based crew vehicles and launch vehicles, including Mercury, Gemini, the Apollo Command and Service Module (CSM),

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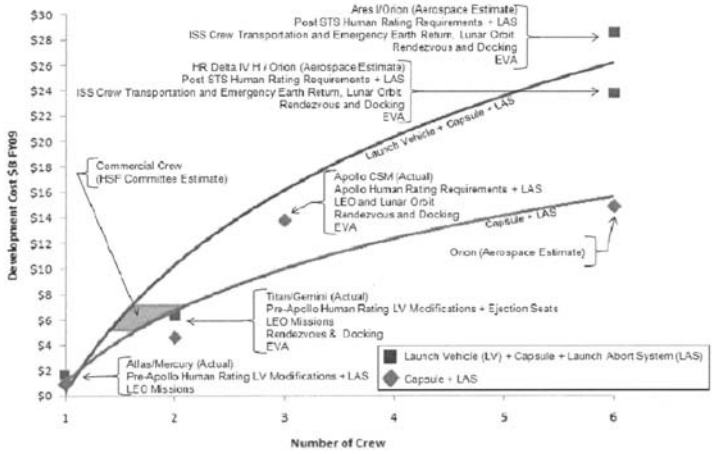
Orion, Ares I/Orion, and Human Rated Delta IV H / Orion [Note: some of these specific examples for which Aerospace developed estimates will be discussed in later sections]. The lower curve (green) illustrates the cost per crew for the capsule and launch abort system (LAS) only. The upper curve (blue) includes the development cost of the launch vehicle. In the case of Mercury, Gemini, and Delta IV H, the launch vehicle costs are for modifications to existing vehicles to meet the definition for human rating in the era in which they were developed. The estimates for Delta IV H, Ares I, and Orion are for a 65th percentile confidence. In general, as the number of crew increases, the systems become more capable in terms of the degree of human rating, mission performance, and other critical capabilities such as rendezvous and docking and Extravehicular Activity (EVA).



For the purposes of illustration, the range of development costs associated with a commercial crew system is assumed to start at the $5B NASA contribution used by the Committee, and extend upward with an assumed commercial investment in these systems. The use of those resources, and a government acquisition approach from the Mercury–Gemini era, suggests that a single transportation system can be developed to transport a crew size of 1-2 to low Earth orbit (LEO). Gemini is the closest historical program to the commercial crew capsule. While we have chosen to plot development cost vs. crew size, the complexity of the system is a function of human-rating requirements, destination and capability including rendezvous and docking, EVA, etc. We would therefore caution against assuming that a 4-crew capsule would necessarily cost in excess of $12B as these other factors would come into play.

The Committee assumed that two commercial crew systems could be developed (starting with three competitors and down-selecting to two successful developments), within this range of resources, using modern commercial acquisition practices.

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d. What would be the likely impact of using the range of costs identified in (c) on the options contained in the Augustine report that assume the use of commercial crew transport services to low Earth orbit? What would be the impact on the costs and timetables associated with those options?

As Aerospace developed our affordability options, we consistently stated that detailed assessments, estimates, and analyses would be required prior to implementing any new option. We also made these same points in our public presentations. However, the Committee did not ask us to determine likely impacts of identified costs and schedules for the commercial crew concept.

The Committee provided an estimated date of 2016 when a commercial crew capability would become available. If this capability were not available by this date, the backup plan was to continue to procure Russian Soyuz's until the commercial crew capability became available. The commercial crew concept relied on private investment to complete DDT&E and amortize fixed costs during operations to meet a price target. Other Orion-based architectures would not involve cost sharing arrangements, and as a government developed, owned and operated system, the government would incur the full burden of cost growth based on historical factors.

e. Has Aerospace performed any assessment or analysis of the total DDT&E cost of a human-rated EELV architecture, including the impact of Ares I close-out costs? If so, what did Aerospace determine the cost to be? Does that include the cost of a dedicated EELV launch pad and other ground support infrastructure, or is it assumed that an existing launch pad will be shared between commercial crew operations and national security/civil launch operations?

In a series of studies performed for NASA that predate the Augustine Committee, Aerospace developed DDT&E costs and lifecycle cost estimates for several human-rated (HR) Delta IV H launch vehicle configurations. Delta IV H was representative of a general class of human-rated Evolved Expendable Launch Vehicle (EELV) launch vehicles. Aerospace was asked to estimate costs to substitute an EELV for Ares I within an Ares I/Ares V architecture. The fact that Ares V was the envisioned end state levied constraints on what options could be considered. Depending on the configuration, DDT&E costs to human rate the Delta IV H range from approximately $5B FY09 to approximately $9B FY09, (65th percentile confidence) not including ground infrastructure development (either new or modified existing) costs. Ground infrastructure development costs were estimated at approximately $2.3B FY09. Aerospace estimated the Ares I contract close-out and contract transition costs to be approximately 0.3 $B FY09. These estimates assumed a conservative interpretation of NASA's human-rating requirements in order to be comparable to Ares I. Furthermore, the launch vehicle and upper stage were sized to lift the fully capable Orion and make maximum use of existing NASA developments including upper stage, test facilities, and Orion avionics. The launch vehicle itself was modified to increase redundancy and margins.

These assumptions are not on a par with what the Committee assumed for "commercial crew" in terms of performance and capability. Most importantly, the Committee assumed the utilization of an existing launch vehicle with flight performance history, whereas the Aerospace EELV studies assumed the launch vehicle would be modified, and a new or modified upper stage would be built.

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None of the options examined assumed that an existing launch pad would be shared between commercial crew operations and national security/civil launch operations. It was assumed that EELV would leverage the existing launch pad infrastructure planned for Ares I.

f. In the absence of program management milestones that are used to track development progress and costs, did Aerospace assume proxy activities would be used by NASA to track DDT&E progress by potential commercial crew transportation service providers? What were these proxy activities and was the cost of implementing them by NASA included?

For the commercial crew transportation services, it was assumed that the COTS A-C activities and milestones were accomplished, and the resultant operational capabilities would be realized as currently planned by NASA. The Committee assumed a one-time $200M investment from NASA to augment the COTS A-C development activities. The commercial crew activities were assumed to be initiated with COTS-D as an open competition that would draw in not only the contractors performing COTS A-C but larger, established aerospace industry contractors. Aerospace made no assumptions regarding program management milestones or proxy activities.

g. What did the analyses in the Augustine report assume would be the per seat cost and price for the commercial crew transport services included in the options? What was the source of the per-seat cost and price estimates?

The Committee provided the commercial crew transport service assumptions that assumed a price of $200M FY09 per flight at a rate of 2 flights per year. Using a historical cost growth factor for operational systems, Aerospace increased the cost per flight to $250M FY09. The Committee did not define the crew capacity of the commercial crew vehicle. Based on the 2 Gemini-class crew module discussed above (see question 1c.), the cost per seat would be on the order of $125M FY09 but would vary with crew size.

h. What size non-NASA market and what non-NASA flight rate were assumed in the per-seat cost and price estimates and resulting cost to the government, and what was the basis of the non-NASA market size and flight rate estimates? Did Aerospace make use of market projections, and if so, who provided those market projections?

Aerospace was not privy to non-NASA market information the Committee might have received other than what was presented in public sessions. We did not see or review any market projections or flight rate estimates during our support of the Committee. To our knowledge, the Committee received testimony from prospective customers that there is a market for commercial crew transportation to LEO for non-NASA purposes if the price is low enough and safety robust enough. The Committee also received testimony from prospective providers that it is technically possible to provide a commercially viable price on a marginal cost basis, given a developed system.

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i. How many competing commercial crew transport systems were assumed to be supported/used in parallel by the government in the options costed by the Augustine panel?

For estimating purposes, the Committee assumed that three contracts were initiated, and one competitor subsequently dropped out.

j. In the Augustine report, what was the total annual cost [from development phase through steady-state operations phase] to the government of the commercial crew transport services included in the options, and what was the source of that cost estimate? Did Aerospace independently validate that cost estimate?

Many of the integrated options incorporated a commercial crew to LEO capability. The Committee defined the NASA costs for the commercial crew transport service to be $3B FY09 DDT&E, with some unspecified amount of private investment to supplement DDT&E and/or ground infrastructure development, along with a $200M FY09 per launch cost. Using historical cost growth factors, Aerospace increased the $3B to approximately $5B, and the $400M per year for operations to the International Space Station was increased to $500M (2 launches).

The total annual cost to the government for commercial crew was based on the affordability analysis on the integrated options provided by the Committee. The $5B allocated for development was spread over 5 years with approximately $1.5B in the peak funding year. The total annual cost during operations was $0.5B per year for two flights per year.

As we stated in our response to question 1c, Aerospace did not independently validate the Committee cost estimate, as our operating parameters stated that other sources of capital would be available to the commercial providers. We did, however, perform a comparison of the Committee cost estimate for the commercial crew system to historical programs as an existence proof of the potential for a system in this cost range.

k. What characteristics were assumed for the commercial crew transport services included in the options—e.g., how many seats for U.S. astronauts per vehicle, how many flights per year, were the flights carrying NASA astronauts dedicated solely to government crew transfer operations, were the vehicles assumed to be reusable or not, and were the vehicles assumed to meet the International Space Station crew rescue stay-time and performance requirements? What infrastructure was assumed to be provided/maintained by the government?

The Committee provided the commercial crew transport service assumption of a rate of 2 flights per year. Explicit assumptions of reusability were not provided. There was no assumption made whether the crew capsule was reusable.

The capsule described by the Committee is a crew "taxi." It takes a crew up to the International Space Station (ISS), or other LEO destinations, and potentially a different crew down to Earth. It is not required to provide long on-orbit storage, leave the LEO environment, provide the higher lift to drag (L/D) ratio needed for superorbital reentry (e.g., lunar return), provide habitat volume,

or provide other accommodations for long duration missions. It would have an on-orbit life independent of the ISS of days to weeks, but potentially be storable at the ISS for months. Other characteristics of the commercial crew transport services envisioned by the Committee such as the manner in which crew were manifested on flights, performance requirements, and infrastructure assumptions were not known to Aerospace.

We operated with the assumption that the "crew taxi" would have the capability to ferry 2-4 astronauts to/from ISS. The uncertainty in number of crew was to allow the maximum number of launch vehicle/capsule combinations to be considered, and not preclude offers at different price and capability points. There was no assumption provided regarding commercial pilots relative to civil servant passengers. The vehicle would fly twice per year at the $200M FY09 per vehicle ($250M with cost growth factor applied) for a total of $500M per year. If the number of seats was on the low end of the range (i.e., 2 crew instead of 4), this would clearly have implications for the number of vehicles that would be required to meet a static requirement and might require more frequent flights of a smaller (but perhaps less costly vehicle).

Question 2. On page 71, the Augustine report states that "a [commercial crew] capability in 2016 could be estimated with reasonable confidence." Was that schedule estimate independently developed or validated by Aerospace or was Aerospace simply directed to use it in subsequent analyses? If the latter, who was the source of the estimate and what was the basis of the estimate?

The Committee provided the schedule estimate for the commercial crew scenario as an input assumption, which was then used for the subsequent affordability analyses. As Aerospace developed and refined our affordability analyses of various Committee options, the Committee formed a working group, that performed fact finding and provided specific assumptions and ground rules for our affordability analyses. Dr. Crawley, as the lead of the working group, gave this information to Aerospace. Estimates to the Committee from providers ranged from three years to five years. This produced a start in early FY2011, assuming a year for program realignment.

Aerospace did not independently develop or verify the schedule estimate for the commercial crew capability.

Question 3. Has Aerospace performed any analysis or assessment of the length of time it would take to develop, demonstrate, and contract for an operational commercial crew transport service for use by U.S. government astronauts? If so, what was the result of that assessment? What would be the impact of using that schedule estimate in the analysis of the options included in the Augustine report?

Aerospace has not performed any analysis or assessment of the length of time it would take to develop, demonstrate, and contract for an operational commercial crew transport service. Aerospace examined the development time associated with human rating the Delta IV H launch vehicle and ground system. In that case, the ground processing and launch infrastructure was the critical path item with a 5-7 year development period, but the human rating modifications for the launch vehicle were close behind. If initiated this year, these estimates are consistent with an operational ground processing and launch infrastructure for commercial crew in the 2016 time frame.

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Question 4. What are the acquisition-related steps that would need to be followed by the government in the development and procurement of as-yet-to-be-developed commercial crew transport services, e.g., development of a COTS-like demonstration program; COTS RFP preparation and release; competition for COTS awards; negotiation of COTS agreements; DDT&E phase; demonstration phase; RFP preparation and release for commercial crew transport contracts; contract competition, award, negotiation, potential protest resolution, etc.; and certification for operations involving U.S. astronauts before commencing commercial crew transport services to the International Space Station? Historically, how long has it taken to complete such acquisition steps in the development of new aerospace systems to be used by the government?

This is a critical question. While we raised these questions in the development of our work for the Committee, we were not tasked to develop this analysis. Subsequent to the release of the Committee Report, we have met with the NASA Administrator and key staff to discuss these issues. To our knowledge, NASA is currently evaluating these steps. Based on Aerospace's prior experiences on a wide range of government acquisition activities, the acquisition-related steps are numerous, and include such steps as described in the Question 4 above. These steps typically take on the order of many months.

Question 5. What role did Aerospace play in the development and analysis of the options contained in the Augustine report? For example, did Aerospace develop all of the assumptions and input data for the different options or were there circumstances under which you were directed to use specific input data or assumptions by members of the Augustine panel? If the latter, what specific input data or assumptions was Aerospace directed to use by panel members and in each case who directed you to use them? Did Aerospace independently validate those input data or assumptions?

Aerospace had no role in the development of Committee options, nor were we present when they were developed. The Committee passed new options to us for affordability analyses as they developed them. A large and diverse NASA and Aerospace team supported the discussions of the ground rules and assumptions for each of the options.

The input data for the options came from a variety of sources. Costs for the various elements were generated by combining data from the Constellation Program (PMR09 and PMR08 Rev1B data) with analogies and additional NASA or Aerospace data sources, when available, to inform the cost data and assumptions for systems that deviated substantially from the Constellation Program.

Our role was to integrate inputs from multiple sources and assure consistent treatment of all elements throughout the assessment process. Aerospace evaluated the manifest for a given integrated option architecture to assure that the number, type, phasing, and size of vehicles were appropriate for the stated mission objectives and destinations. Costs for government-developed systems were benchmarked against data that Aerospace and/or the NASA analysis team had access to. Aerospace used analysis products from studies performed to answer earlier Committee questions on the Constellation Program, International Space Station (ISS), and launch vehicle concepts to cross-check the Committee inputs. The EELV human-rating studies, which pre-date the Augustine Committee, were used as appropriate to estimate EELV-based architectures and capture infrastructure and industrial base maintenance costs. NASA estimated shut down and transition costs were included as appropriate.

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Question 6. What is required to be able to proceed to carry out any of the options included in the Augustine report with a high confidence level understanding of its cost and schedule? Given the time and resource constraints that Aerospace faced, what is the difference between what Aerospace did to support the development of the options and what is needed for a high confidence level understanding of the cost and schedule of each option?

As stated previously in this response, to the Committee, in public, and to the NASA Administrator, the only appropriate forward path is to develop detailed program baselines. These include detailed schedules, program baseline cost estimates, independent cost estimates, and comprehensive discussions with potential vendors. This is the normal approach Aerospace takes and the process requires several months after a program baseline is developed.

Our work in support of the Committee was at a higher, more general level. The Committee repeatedly stressed to Aerospace that we were not directed to develop executable baselines, schedules, and costs. Rather, we were to treat various options as consistently as possible to allow the Committee to develop top level findings, such as an assessment of the technical risk posture for Constellation as currently being performed, budget availability to execute the program of record, and general availability dates for other options (some of which had not entered the design phase). We realize the tendency to treat Aerospace's work as executable baselines. While we stand solidly behind the work we did for the Committee, it is important to reiterate what we were asked to accomplish.

Given the schedule constraints on the Committee, Aerospace performed cost and schedule analyses at the appropriate level to address the high-level questions posed within the compressed timelines. Certainly, with more time and resources, analyses with greater fidelity could have been performed. However, Aerospace did not determine the time and resources required to provide more detailed cost and schedule analyses of each option.

Question 7. How was the confidence gained from actual progress in completing DDT&E activities factored into Aerospace's cost and schedule estimates for options incorporating the program of record?

Aerospace built cost baselines for each of the scenarios that incorporated data from a variety of sources, including NASA-supplied data, estimates generated by Aerospace, and assumptions defined by the Committee members. Historical mean cost growth factors based on actual historical performance of 77 NASA system developments were derived. These factors were applied consistently and appropriately across the options, taking into account systems already in development, such as Constellation, versus concepts in earlier stages of development. Credit for cost growth already incurred is applied to Constellation program elements that are underway. In contrast, the historical cost growth factor is applied in full for projects not yet initiated.

Question 8. How long did Aerospace have to carry out the cost estimation and schedule analyses for each of the options considered by the Augustine panel? What caveats, if any, would Aerospace apply to the results of its analyses?

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Aerospace's team supported the Committee on a compressed timeline when evaluating the affordability of integrated options. The full set of options evaluated included, but were not limited to, the Constellation Program and other architectures that targeted various beyond LEO destinations, including: lunar surface, Near Earth Objects (NEOs), Lagrange points, and others. These cases were analyzed over the course of several weeks.

The framework for the affordability analysis was assembled from existing software, databases and algorithms over the course of a couple of months. It benefited from several years of Aerospace and NASA investment. Once the framework was established and validated, the affordability analyses for each of the integrated options provided by the Committee were performed on short timelines, typically a few days. In order to compare in-development systems with "paper concepts," a uniform affordability analysis methodology, informed with historical cost growth data, was applied to each option. Our direction from the Committee was to focus on capturing the macro-level issues versus delving into substantial detail on various systems.

As previously stated, our only caveat was that these analyses were directed and developed to be used as guideposts for comparison among options. We do not claim them to be traditional independent analyses of all the elements of each program.

Question 9. Did Aerospace perform an Independent Cost Estimate (ICE) or Independent Schedule Estimate (ISE) for the Constellation program or its major elements? What would be required to do an ICE and ISE, and how long does Aerospace estimate it would take to complete them?

Aerospace did not perform a traditional parametric or grass-roots Independent Cost Estimate (ICE) or Independent Schedule Estimate (ISE) for the Constellation Program or its major elements. In order to perform an ICE/ISE for the Constellation Program or its major elements, Aerospace would require technical, design and programmatic data depending upon the phase of the project. The required elements for an ICE/ISE include: design description documents, project Work Breakdown Structure (WBS) definitions and descriptions, Master Equipment Lists (MEL) containing mass, a description of power modes by subsystem, a block diagram of launch vehicle and capsule (or other elements), descriptions of the launch vehicle and capsule subsystem including heritage, lists of hardware suppliers, and an Integrated Master Schedule with major development milestones.

Based on past experience that includes ICE assessments of elements of the Constellation Program such as Ares V and Altair, an ICE/ISE of the Program or its major elements would typically be a multi-month (~3 to 6 month) process. A traditional ICE/ISE also includes a project and/or program level reconciliation. Aerospace was tasked to perform a high-level schedule assessment of Constellation, which found that there was a potential 3-4 year impact to the Orion / Ares I Initial Operational Capability (IOC) milestone due to the effects of the FY10 budget reduction, technical cost-risks, and ISS extension to 2020.

Question 10. What would be required to do an ICE and ISE for a proposed commercial crew transport system, and how long does Aerospace estimate it would take to complete them?

The data and timeline required to perform an ICE/ISE for a proposed commercial crew transport system depends on the level of maturity of the systems and the technical and programmatic

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data available for the assessment. For systems early in their development lifecycle or with a limited amount of available data, the time required to perform these analysis may be less than estimated in Question 9, but may have a higher level of uncertainty in the results. For more mature designs, with a larger set of technical and programmatic data, the time to conduct a complete analysis may be similar to those required to perform an ICE/ISE for the Constellation Program and its major elements (please see Question 9).

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