

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

**HEARING CHARTER**

*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 cancelling 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 cancelling 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 projections 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 5-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 identify 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 January 2010, NASA reported that it had spent a total of about \$9 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 4 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 meeting, NASA informed the Subcommittee that the Constellation Program PDR 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 where-with-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 administration 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 assumed 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 1990’s 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 parts of the trajectory, where an abort is non-survivable, 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 real-time 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 exploration 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.