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

July 23, 2014

Reply to Attn of: Office of Communication
Headquarters FOIA Office

FOIA: 14-HQ-F-00652

Thank you for your Freedom of Information Act (FOIA) request dated June 15, 2014, and received in our office June 27, 2014. Your request was for:

> a copy of each response to a Question for the Record (QFR) provided to Congress by NASA. (By responses to QFRs, I mean the responses to formal questions posed in association with testimony before a Congressional Committee.) These records are most likely maintained in the Office of Congressional Affairs, Office of Legislative Affairs, Office of Intergovernmental Affairs, or equivalent, or in the executive secretariat.
>
> You may limit this request to records created since January 1, 2009. If this request will. require extensive searches, please contact me so we can discuss narrowing of the request. If this will produce voluminous records, please limit the request to records created since January 1, 2012.

The NASA Headquarters program office (s) conducted a search for Agency records using the above listing as its search criteria. We are releasing in full 27 documents consisting of 403 pages of responsive documents for your request.

Fees for processing this request is $30.00 and is being charged in accordance with 14 CFR § 1206.700(i)(2).

Please contact me at hq-foia@nasa.gov or (202) 358-2462 for further assistance.

Sincerely,

Josephine Sibley
Headquarters FOIA Officer

Questions for Mr. Rick Howard
December 6, 2011 Hearing on
The Next Great Observatory:
Assessing the James Webb Space Telescope

From Chairman Ralph Hall

1. Despite the tough fiscal environment, NASA received the full amount requested for JWST in FY 2012 as budgeted in the re-plan. However, we cannot be certain that future Congress's will appropriate the amount requested in the out-year budgets. What impact would reduced funding have on your ability to launch JWST in October 2018 as planned?

Response: Stability of the funding profile is a critical factor in determining the success of the new cost and schedule baseline for JWST. Any reduction in future years' appropriations will directly increase the risk of completing the development of JWST within the cost and schedule established in the new baseline. Adjustments to the funding profile from year to year or reductions in funding will nullify the Joint Cost and Schedule Confidence Level (JCL) assessment that was done on the new baseline and assessed by both NASA and the independent Standing Review Board. These assessments were used as the basis of the Agency position that the new baseline is robust and has a high level of confidence. NASA ability to keep the total formulation and development cost capped at $8.0B as directed by Congress would have to be reexamined.

2. During the hearing mention was made of a number of missions that have been impacted substantially by JWST. Mention was made of missions like TPF, SIM, IXO, LISA, and WFIRST, though others were also named, particularly in the planetary arena. Please comment on the impact, if any, that JWST had on the progress on such major NASA science missions.

Response: NASA Astrophysics investments are informed by the National Academy of Science's decadal survey reports. The 2001 report *Astronomy and Astrophysics for the New Millennium,* recommended JWST as its top priority space-based major initiative. Historically, NASA has developed its 'flagship missions' serially. Hubble was the first, followed by the Chandra X-ray Observatory, and later the Spitzer Space Telescope. The NASA Astrophysics budget has never accommodated simultaneous development of flagship class missions. This is done to maintain the community recommended balance between large and small missions in development, missions in operation, and research and analysis funding. All of the other missions mentioned in your question are flagship class observatories, which would have compromised the recommended balance in funding the Astrophysics program. In the most recent decadal survey report, *New Worlds, New Horizons in Astronomy and Astrophysics*, the astronomical community selected WFIRST as the highest priority space-based large-scale activity after JWST. Other missions were ranked third or lower in priority for investment, and in some cases (SIM, TPF, other planet finder missions) dropped completely from mission development recommendations. For example, ESA terminated their participation in LISA and IXO following the low rankings of those missions in the 2010 decadal survey. Thus, of the Astrophysics missions mentioned above, only WFIRST was directly affected by the expected JWST cost growth and schedule delay in the FY 2012 President's Budget Request, which was released in February 2011 (before the development of the new JWST baseline). Given current fiscal constraints, NASA cannot undertake development of WFIRST until development of JWST is complete. NASA is continuing initial planning efforts to further define WFIRST concepts and science goals. For example, NASA has undertaken a science definition study of WFIRST that will be completed by the end of this year.

From Representative Lamar Smith

1. NASA recently announced that the Kepler Space Telescope has discovered an Earth-like planet 600 light years away whose size and distance from its own star put it in the "habitable zone" to support life. The Hubble Space Telescope has made countless discoveries over the past two decades.
    a. What kinds of scientific revelations might we anticipate with the James Webb Space Telescope, compared to those from Kepler and Hubble? Would you recommend maintaining operations of the Kepler and Hubble Space Telescopes even if funds from those missions are needed to be used to keep JWST on track?

Response: Prior to the launch of Hubble no one knew all the amazing discoveries it would ultimately make. Similarly, JWST's discovery potential is even greater than Hubble's. Like Hubble, JWST will be a general observer facility with observations selected through competitive peer-review. Therefore, we cannot predict exactly what discoveries JWST will make. However, the JWST design has been guided by four scientifically compelling themes: detection and characterization of the first stars and galaxies to form after the Big Bang, the build up and evolution of galaxies across cosmic time, the birth of stars and planetary systems in our Galaxy, and the study of our solar system and of exoplanets. In each of these areas JWST's unmatched combination of wavelength coverage (near to mid-infrared), collecting aperture (6.5m diameter), and sensitivity will permit scientists to see things invisible or undetectable with any existing or planned facility – even Hubble. The Kepler mission is very different from both Hubble and JWST because it stares at one point in the sky and makes extremely accurate measurements of the brightness variations of sources in its field of view. These brightness variations tell us about planets orbiting stars and about how stars themselves vary in brightness with time. While each contributes valuable science, Hubble, Kepler and JWST perform complementary, non-overlapping missions.

The longevity of NASA Astrophysics missions is determined both by the performance of the hardware over time, but also through a peer-review competition with other missions which have met their primary science goals. Every two years NASA conducts a Senior Review of its operating missions in their extended operations phase. The most scientifically useful missions are recommended for extension. Those missions whose scientific return is no longer deemed as compelling receive reduced or no additional funding for extended operations. Thus the decision to extend missions is based upon scientific importance rather than merely the "gap-filling" aspect. Kepler's prime mission is scheduled for completion in November 2012, and continued operation is dependent on results of the Astrophysics Senior Review of operating missions to be held this year. Then Kepler, Hubble and all other Astrophysics operating missions will be reviewed in order to determine whether the continued science return is worth the investment in the context of the entire Astrophysics portfolio.

    b. Could you comment on the role of JWST in maintaining and expanding U.S. global leadership in astronomy and astrophysics?

Response: JWST will be the largest and most technologically complex scientific satellite ever developed. Because of its unprecedented collecting area and cutting edge technology science instruments, JWST will enable science investigations that probe fundamental questions about the origins of stars and galaxies and begin the detailed study of exoplanet atmospheres searching for signatures of life. As Dr. Roger Blandford noted in his testimony to the Committee, JWST is a cornerstone of the 2010 National Research Council decadal survey in Astrophysics. The survey assumed a fully functioning JWST. No other nation could lead the development of a space-based observatory of the complexity and scale of JWST. It will keep NASA and the US on the forefront of space-based astronomy and astrophysics. The new technologies developed for JWST including deployable cryogenic mirrors, microshutter devices, and ultra high sensitivity near and mid infrared detectors demonstrate U.S. leadership in this area. When these technologies are assembled into JWST they will create an observatory with sensitivity 100 times greater than that of Hubble.

As an additional example of U.S. leadership fostered by investments in JWST, ESA and NASA has agreed to discuss US participation in its *Euclid* mission in the area of detectors. The detector electronics ESA is considering are derived from those developed for JWST. Thus NASA and the US astronomy community would gain a "seat at the table" with ESA's *Euclid* science team by virtue of JWST derived technology.

Clearly, Hubble and other Great Observatories have been a huge success and cemented the US leadership role for space astrophysics. JWST will continue that success and position US industry and academia well for the next advances that will follow.

c. How do the Hubble, Kepler and Webb Space Telescopes compare to the capabilities of the European Space Agency's Herschel telescope?

Response: The European Space Agency's (ESA) Herschel Telescope is a 3.5m diameter telescope that operates between the wavelengths 55 to 672 microns (the mid-to-far infrared) and, because it uses stored cryogens, has a roughly three-year lifetime. The angular resolution is at best comparable to ground-based telescopes because of the longer wavelengths and relatively small mirror diameter (for those wavelengths). Herschel will make important advances, but in areas that are distinct from those that JWST is optimized for such as very high angular resolution near infrared observations of faint sources. JWST works from ~0.6 to 28.5 microns (near infrared to mid infrared) and will return images as sharp as those returned today by Hubble. As stated above, Kepler is designed to stare at one specific region of space over its primary mission lifetime, whereas Hubble, Webb, and Herschel are designed to point at many different areas and objects of interest over their lifetimes. Hubble is optimized to observe in the visible and ultraviolet portions of the spectrum. Each of these facilities possesses unique strengths that permit different astronomical phenomena to be studied. They are truly complementary rather than competitive.

d. What are other nations doing in astronomy and astrophysics that could jeopardize America's leadership in the field?

Response: NASA and other space faring nations routinely work collaboratively on missions taking advantage of the capabilities of each organization to improve the science return from most of our missions. Indeed, approximately 85 percent of recent NASA astrophysics missions involved partnerships with other countries. NASA has for years led the world in the development of astrophysics missions in terms of capability. ESA and others are developing increasingly more sophisticated systems that are approaching and in some cases exceeding US capabilities. However, JWST represents an unmatched leap in science capabilities because of its revolutionary technological advances in large deployable mirrors and cryogenic operations.

ESA is moving ahead with its *Euclid* dark energy mission, and NASA (consistent with the recommendation of a recent NRC report) is considering participation at a modest level in that mission. Japan has an active interest in space-based X-ray astronomy, and NASA has long partnered with them in their program. Currently, NASA is developing an instrument to fly on Japan's Astro-H mission in 2014. Both ESA and JAXA have plans for more complex and larger missions in their plans as well.

Other nations have recognized the often broadly applicable technology developed in support of astronomy missions. As they strengthen their investments in those areas (detector development, large mirror construction) they will catch the United States if we do not similarly maintain our investments in leading edge science and technology. Moreover, the world's best and brightest scientists and engineers watch and follow where the most exciting new work is being done. To ensure that we capture those exceptional individuals it is critical that the US be the place where cutting edge work is being performed.

2. Last July, NASA's associate administrator Ed Weiler, who was in charge of NASA's science mission budget of almost $5B annually, called the Obama Administration's flat budget for the James Webb Space Telescope a "road to nowhere" in a press interview. Soon thereafter, Dr. Weiler tendered his resignation, after 33 years of service to NASA.
    a. What are your thoughts of how the Obama Administration handled the budget challenges for the James Webb Space Telescope over the past 3 years?

Response: The Administration has been supportive of JWST. It allowed NASA's process of review and establishment of a new cost and schedule baseline to run its course, then worked closely with NASA to find a solution for funding the new baseline within NASA's top-line budget. The FY 2013 budget request fully supports that new baseline.

    b. Why did the annual funding for the JWST drop during the Obama Administration compared to how much was being spent on the JWST only a few years ago? Shouldn't the funding profile for the Webb telescope have been increasing as the project was ramping up? (FYI:

$438M was spent in FY 2010 for JWST, but only $354.6M was requested in FY 2011)

Response: The Administration's FY 2011 budget request for JWST was $444.8M, up from the $385M that was projected for FY 2011 in the FY 2010 budget request. At that time (February 2010), NASA was still working to the old baseline schedule that assumed a 2014 launch and its associated budget profile. The flat-line budget was a placeholder for the out-years in the FY 2012 budget request pending the re-plan activity. At that time (February 2011), NASA was undertaking a re-plan of the JWST program.

c. Did this flat-line budget from the Obama Administration cause delays to the program? If so, how much delay?

Response: The flat-line budget in the FY 2012 budget request was a placeholder while the new cost and schedule baseline was being developed. The FY 2011 and FY 2012 President's Budget Request funding levels were the only initial constraints in developing the new baseline. The resulting baseline, which included adequate schedule reserves, supported an October 2018 LRD but had an unrealistic funding profile from FY 2012 to FY 2013. The final baseline approved by NASA in September 2011 included adjustments to the FY 2011 and FY 2012 funding that were above the President's budget for those years in order to provide a more executable profile and work plan. To support the October 2018 launch date and the budget profile established in the new baseline, the Administration added $44M in FY 2011. These additional funds, along with those provided in 2012, allowed NASA to accelerate work, retiring risk and saving resources, and to maintain the cost and schedule confidence level of the new baseline.

d. Did the House Appropriations Committee provide an adequate wake-up call for the Obama Administration and Congress that the budget challenge facing the James Webb Space Telescope required fixing?

Response: The Administration had already begun a re-plan of JWST in response to the budget challenges associated with the project. House Appropriations Committee actions regarding the FY 2012 budget lent an additional sense of urgency.

From Representative Larry Bucshon

1. We heard testimony indicating that the James Webb Space Telescope is both grossly over budget and significantly past deadline. Further all of the panelists noted varying degrees of program mismanagement that have resulted in these expenditures and delays. Therefore, I'd like to ask that you supply my office, and this committee with a detailed receipt of how last year's budget was spent. I would like that budget to include detailed explanations of what work was completed and its cost, the cost of the components, labor, materials and how each directly builds toward the hopeful end result of an operational telescope.

Response: The Independent Comprehensive Review Panel report noted the excellent technical progress of the project to-date, but identified several management problems, which have been fully acknowledged and corrected by NASA. Once these corrective measures were put into place early in 2011, the new JWST Program Director worked with the JWST Project Office at the Goddard Space Flight Center and with the prime contractor to identify a set of technical milestones to be accomplished in FY 2011. This served to assure that good progress would be made toward launch while the new baseline cost and schedule was being formulated and reviewed. That list of milestones is shown in the chart below.

JWST FY 2011 Milestones

Month	Milestone	Comment
Jan '11	Ship Mid-Infrared Instrument (MIRI) Focal Plane Electronics to ESA (Rutherford Appleton Lab.)	Successfully Completed - 1/24
	Ball's Flight Actuator Drive Unit Software Test Review	Successfully Completed – 1/20
Feb '11	Deliver Near-Infrared Spectrograph flight spare detector to GSFC	Successfully Completed – 1/29
	Pathfinder Primary Mirror Backplane Support Structure delivered to Northrop-Grumman Aerospace Sys.	Pathfinder delivered to NGAS on 3/25
	Establish No-Earlier-Than Launch Readiness Date (LRD) as part of replan	Based on current funding constraints a NET LRD of Oct. 2018 established, FY 2011 and FY 2012 schedule does not preclude an earlier date if deemed possible in the future – Completed 2/25
	Establish Work Breakdown Structure for new GSFC responsibilities	Successfully Completed – 2/28
Mar '11	Complete flight ISIM Remote Services Unit Thermal Vacuum testing	Successfully Completed – 2/19
	Deliver Fine Guidance Sensor (FGS) test unit electronics to ISIM Integration & Test (I&T)	Successfully Completed – 2/24
	Complete 2018 LRD budget details	Preliminary Budget was presented to Program Office and Center Management on 4/7
Apr '11	Pathfinder Primary Mirror Segment Assemblies complete	Successfully Completed - 4/25
	Deliver ISIM Command & Data Handling test unit to ISIM I&T	Successfully Completed – 4/22
	Complete 2018 LRD project lead Joint cost & schedule Confidence Limit (JCL)	Initial JCL run completed – 4/28
May "11	Start flight FGS environmental testing (instrument level)	Successfully Completed - 5/4
	Complete Spacecraft Secondary Mirror Segment Cone Structure internal Design Review 3/4	Successfully completed – 4/20

Jun '11	Complete Common Command & Telemetry System Build 2.3 Start ISIM level I&T	Successfully completed – 4/13 Successfully Completed - 6/24 Began the ISIM Flight I&T with the integration of the Spacecraft Simulator 2A (SCSIM-2A) into the Flight Electrical Environment.
Jul '11	Deliver ISIM Region 1 Wiring Harnesses Deliver ISIM Structure to ISIM I&T	Successfully completed – 7/22 Successfully completed – 7/28
Aug '11	Spacecraft Flight Software Build 1 Technical Readiness Review	Successfully Completed – 6/30
Sept '11	Deliver Flight ISIM Electronics Compartment to ISIM I&T Deliver flight ISIM Command & Data Handling unit #1 to ISIM I&T	Delayed due to design changes Completed – 9/27

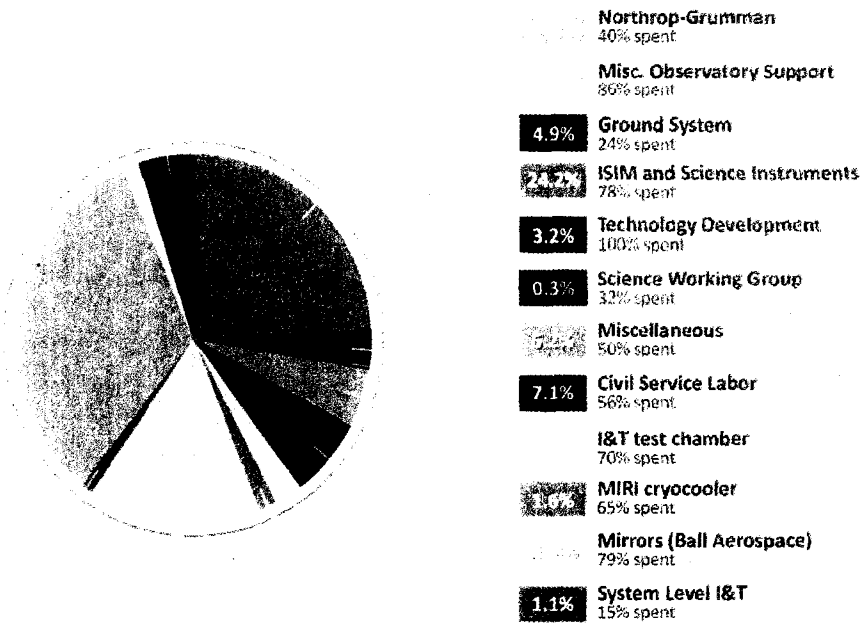
As shown in the chart, all but one of these milestones were accomplished. The cost of these and related activities in FY 2011 is shown in the table below.

JWST FY 2011 Expenditures

	FY11	Actual Obs. FY11
Labor & Related Expenses	21,050	20,800
JWST Program Office	1,300	700
Project Support & MPS	8,192	6,700
Observatory Systems Engineering	10,734	7,200
Safety & Mission Assurance	4,624	3,700
Science & SWG	1,915	1,700
ISIM	80,903	78,800
Observatory	273,394	277,500
OTE	8,673	5,800
Launch Vehicle Accommodations	65	-
Ground Segment	37,244	41,300
Systems Integration & Test	11,049	7,900
OTE/ISIM (OTIS) Integration & Test	14,200	18,300
Contingency	3,414	
Sub-Total JWST	**476,756**	**470,400**
JSC Chamber A Mods	38,500	38,500
Total JWST	**515,256**	**508,900**

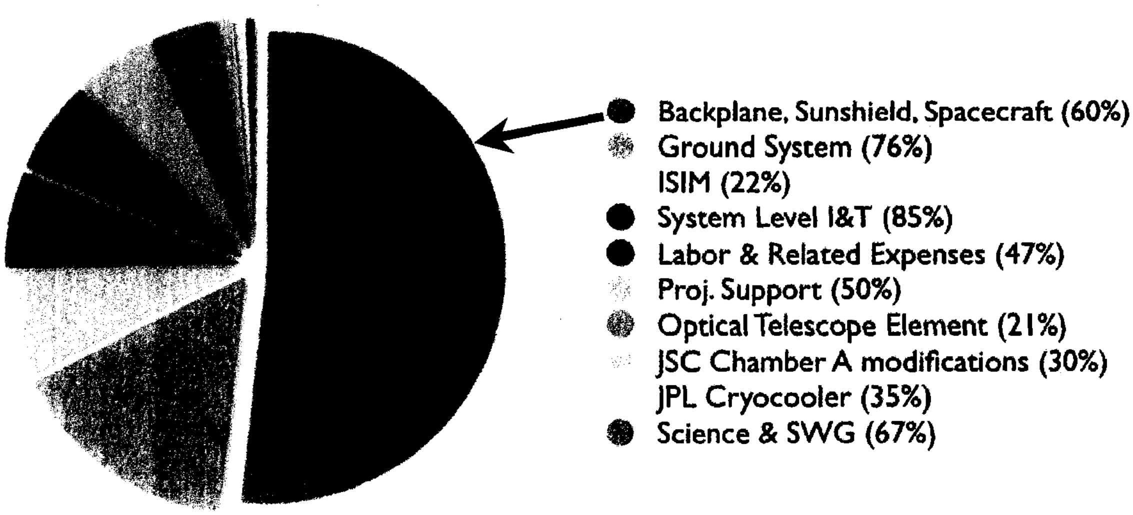
The following chart displays the cost breakdown for the entire amount invested in JWST from its inception through the end of FY 2011.

Cost Breakdown By Element Through FY 2011 ($3.5B total)



Finally, the following chart displays a percentage breakout by cost of major activities of the work yet to be completed on JWST, from FY 2012 through launch and commissioning (i.e., up to the beginning of science operations).

Work-to-Go (FY 2012 through launch and commissioning)



Relative Proportion of Project Funding to Go Percentage Work to Go by Project Element

From Ranking Member Eddie Bernice Johnson

1. The Joint Explanatory Statement of the FY 2012 Commerce, Justice, Science, and Related Agencies Appropriations Conference Committee recently urged NASA to look at lessons learned from reviews of the challenges of prior flagship projects; identify those lessons that address universal management issues; and implement those lessons in flagship projects across the Directorate. How do you plan to undertake the conferees' direction?

Response: NASA is examining its performance on flagship science missions and has already begun changing its processes to better manage technical, cost, and schedule risk. Flagship missions provide significant science return, but cost and schedule management of them has been problematic due to the variety of factors that affect them during their development life cycle. By definition, flagship missions are first-of-a-kind missions that are extending the state of the art in science and technology. In all cases investments are made in the critical enabling technologies to assure that the mission objectives can be achieved. However difficulties still arise as the development progresses because of the complexity of these missions. As an example, the requirement for JWST to operate at cryogenic temperatures meant that many of the traditional manufacturing process and procedures for large space telescopes were inadequate for this temperature regime. NASA and its partners took the leadership in developing these tests and procedures for various elements of the observatory including the composite structures, mirrors, and science instruments. Also flagship missions tend to have longer development times that make them more susceptible to economic changes and leadership changes that can result in challenges for the project. The complexity, uniqueness, and longer development times of flagship missions complicates our ability to establish cost and schedule baselines early in the development cycle. Clearly the results from these missions have proven to be of great value to our nation and the world. As examples consider the long and enormously high scientific productivity of Hubble, Cassini, and other large missions. Their challenging nature is evident as well. In many cases, as with the Mars Science Laboratory, the challenges are technical in nature (for example, in defining optimal heat shield materials, design and manufacturability of wheel actuators, and avionics development).

The steps NASA has taken and is taking to address lessons learned in flagship mission development are summarized here and, for JWST, are detailed in the answers to the questions that follow:

- Establishment of joint cost and schedule confidence level (JCL)-based life cycle cost budgeting that improve the understanding of the complexities and risks associated with a development result in more accurate estimates of cost and schedule as evidenced by the recent performance of Juno;
- Requirement that projects implement Earned Value Management (EVM) systems to weigh technical progress against expenditure of funds on a monthly basis provide early indicators of issues;
- Extended duration Phase B definition and preliminary design to allow for

technology maturation and through system engineering to better characterize the risks to be retired during development and identify unique integration and test needs;

- Use of a formal acquisition strategy process before and during Phase A to define program management structure and Center and contractor roles in a way that best fit the project under consideration;
- Strong independent reviews at key points in the development to verify that the project is making progress per its plan and to offer additional insights based on the independent review teams experience; and,
- Regular reviews with senior NASA management to assure that project concerns are addressed quickly to avoid cost and schedule implications.

Flagship missions enable a broad variety of scientific investigations by carrying large, multi-purpose capabilities like JWST or large numbers of instruments like MSL or Cassini, and are therefore the most scientifically powerful missions NASA undertakes. They accomplish science objectives that no other approach can meet. They also develop technologies that smaller, competed missions can use in the future. As they are by nature one-of-a-kind, they present unique challenges for cost estimation and control. NASA has learned much from those it has developed as well as from JWST now underway, and we are committed to implementing those lessons learned on current and future missions.

2. The report of the Independent Comprehensive Review Panel (ICRP) makes repeated references to the lack of a cost and programmatic analysis capability at NASA Headquarters as a contributing factor in the JWST budget and schedule problems. For example, the ICRP states "*The flaw in the Project Budget should have been revealed as part of the Confirmation process. The fact that it was not reflects the lack of an effective cost and programmatic analysis capability at HQ* [headquarters]. *This too requires immediate corrective action.*" According to the ICRP report, NASA has not had this capability for over a decade.

    a. What has NASA done to act on this recommendation and what, if any, additional plans does NASA have regarding its cost and programmatic analysis capability?

Response: NASA agreed with the ICRP recommendation regarding cost and programmatic analysis capability. NASA has enhanced its programmatic analysis in the new Office of Evaluation, Office of the Chief Engineer (OCE), and the Office of the Chief Financial Officer (OCFO). These offices perform independent analyses and assessments that are reported to NASA senior leaders and program management experts in a monthly Baseline Performance Review and during Key Decision Point reviews. NASA has implemented a cost and schedule database that records key project parameters, such as independent cost estimates and key schedule milestones so analysts may readily analyze and compare ongoing project performance to prior estimates and commitments. Variance analyses are provided to enable managers to identify issues and take action to mitigate their consequences.

b. What has changed in how projects get confirmed at NASA to avoid repeating what happened with JWST?

Response: NASA began to change its policies regarding cost and schedule analysis and assessments made as part of the confirmation process and establishment of a baseline for a mission. The changes mentioned above have been implemented with success on recent projects such as Juno and GRAIL. However, NASA continues to evaluate its performance to improve its program and project management processes to assure that confirmation of a project is justified through analysis. The Policy for NASA Acquisition (NPR 1000.5A) states programs and projects are to be baselined or rebaselined and budgeted based on a joint cost and schedule probabilistic analysis developed by the program or project in accordance with the following:

- Programs are to be baselined or rebaselined and budgeted at a joint cost and schedule confidence level of 70 percent or the level approved by the decision authority of the responsible Agency-level management council. For a 70 percent joint cost and schedule confidence level, this is the point on the joint cost and schedule probability distribution where there is a 70 percent probability that the project will be completed at or lower than the estimated amount and at or before the projected schedule. The basis for a confidence level less than 70 percent is to be formally documented.
- Projects are to be baselined or rebaselined and budgeted at a joint cost and schedule confidence level consistent with the program's confidence level.
- Joint cost and schedule confidence levels are to be developed and maintained for the life cycle cost (at the approved confidence level) and schedule associated with the initial lifecycle baselines (e.g., for space flight programs and projects baselines established at KDP-1 for entry into the development phase of a multi-project program, or KDP-C for a single project).
- A Joint Cost and Schedule Confidence Level is a quantitative probability statement about the ability of a project to meet its cost and schedule targets. Simply put, a JCL is the probability that the cost will be less or equal to the targeted cost AND that the schedule will be equal or less than the targeted schedule date. The process of developing a JCL requires that the project combine their cost, schedule and risk into a complete quantitative picture that helps the decision makers understand the project's prospects for success in achieving their cost and schedule goals. The technique identifies the project-specific risks and allows decision makers to better understand those risks and the context for establishing the project's phased funding requirements.

In addition, the NASA Procedural Requirement for Program and Project Management (NPR 7120.5) is being revised to better identify work that is to be completed during Phase B and more rigorously evaluating whether that work has been satisfactorily completed prior to approving the project for implementation. By better understanding the requirements and the risks associated with projects, the resources and schedule needed to implement the projects can be more reliably sized. Confirmation of significant NASA projects now requires rigorous analyses be performed to confirm that the cost and schedule estimations have incorporated thorough risk assessments. NASA now requires that these analyses of a project's joint confidence levels (cost and schedule) be independently reviewed prior to confirmation and the results of the review are assessed during the confirmation. NASA has established that some projects, like JWST, should be planned with high confidence levels.

Consistent with these policies and procedures, the revised plan for JWST was approved with a joint confidence level of 66 percent (following Agency policy as described above) and a cost confidence significantly higher than the 80 percent recommended by the ICRP (cost confidence levels refer only to the cost portion of the estimate and are independent of the schedule). The cost profile and October 2018 launch readiness date were found to be a sound plan by Goddard center management, the Science Mission Directorate, the independent Standing Review Board and senior management at NASA Headquarters.

3. The ICRP report raised a number of concerns about the oversight and governance of the JWST project within NASA. Is there an independent body that reviews the progress on JWST, and if so have they reviewed NASA's new plan and cost estimate?

Response: Yes, there is a Standing Review Board (SRB) for JWST that was involved in the review of the new baseline including the risks and risk matrix used to generate the JCL and the results of the JCL. The SRB presented their assessment of the new baseline including the results of the JCL to NASA management as part of the Agency's review of the new baseline. The SRB continues to review the technical and programmatic progress and issues of the program.

   a. What was their response to the plan and did they issue any findings and recommendations for NASA on the new plan?

The Standing Review Board issued three findings and one recommendation. The Board found that the project technical baseline reflected that JWST was at the CDR phase of development with some exceptions. They found that NASA had taken positive agency, program, and project-level management steps to reduce program risk. No recommendations accompanied these two findings. The Board found that the replan initially presented to them as constrained by the FY 2011 and FY 2012 funding guidelines was seriously flawed and recommended increasing FY 2011-2012 funding, by applying no less than 30 percent reserves throughout the program to account for unknown risk, and reducing the FY 2013 funding peak by shifting critical efforts into FY 2012 and adjusting the out-year funding profile accordingly. The final plan was reviewed by a sub set of the SRB and agreed that it addressed the SRB concerns.

   b. How has NASA responded to those findings and recommendations?

Response: NASA responded to this finding by revising the baseline to provide additional resources in FY 2011 and FY 2012 (including rephasing work content from FY 2013 into FY 2012 which reduced the FY 2013 funding requirement) and adding additional unallocated future expenditures (UFE) in FY 2014 and out. The SRB reviewed this revised baseline and determined that this was a positive step towards successful planning and implementation of JWST. The rephasing of work along with the additional UFE in the new baseline resulted in a cost confidence level that is significantly higher than the 80 percent recommended by the ICRP. That revised budget profile became part of the new (current) cost and schedule baseline. UFE allocation is phased throughout the project lifecycle to enable management of risks and uncertainties associated with each lifecycle phase. NASA distinguishes UFE funds managed by the project and UFE funds managed by the program responsible for the project. The UFE managed by the project is needed to cover risks and uncertainties that could be reasonably viewed as under the project's control. The UFE managed by the program is needed to address risks and uncertainties that are beyond the projects control i.e. partner's schedule delays or growth in launch vehicle costs.

4. The ICRP noted that the JWST science team had not played a significant role in providing inputs to difficult trade-offs regarding JWST's scientific performance and recommended that their role be strengthened. Please describe what changes have been made to increase the science team's role.

Response: As we reported in our response to the ICRP recommendations, NASA has added a Deputy Senior Project Scientist/Technical position to the project science team. This individual is responsible for day-to-day interactions with senior project management on all aspects of the mission; scientific, technical, budgetary, and schedule. This individual also regularly meets with other members of the project science team to ensure rapid and substantive communication between the science and cost/schedule/risk worlds. This new position assists the Senior Project Scientist to better integrate the science activities with the hardware development activities to enable closer coordination and understanding of technical drivers to science performance so fully informed decisions can be made.

In addition, the Senior Project Scientist at Goddard Space Flight Center now reports directly to the Center Director, and project scientists make monthly technical reports within the project. The science team members work closely with their managerial and engineering counterparts in all areas of the international JWST Project to find technical solutions that ensure that the agreed scientific performance requirements are met.

5. We often hear about the importance of having challenging space projects to sustain the skilled workforce in this nation. What, in your view does JWST mean for our workforce and for those young people who will become our workforce in the future?

Response: JWST is the next-generation astrophysics mission, more powerful than any science mission humans have launched into space. JWST represents a substantial advance in technology and observing capability. JWST will change the way future space telescopes are built and tested because: it represents the first instance of a telescope whose mirror diameter is larger than the launch vehicles fairing and because of its size it cannot be tested as a unit in one test chamber, it therefore represents the first mission that relies on a complex multi-stage integration and test program combined with sophisticated computer modeling to verify observatory performance before launch. Both of these features, rocket fairing limitations, and vacuum test chamber sizes were fundamental limitations on telescopes before. JWST developed technology along with new processes and procedures to break those limitations and free future scientist and engineers to think about space observatories in a new way. Young scientists and engineers will be able to build on that to develop even more powerful science instruments over the next few decades. Students will be inspired by JWST science results to themselves study science and engineering (as today's early career workforce was inspired by Hubble). They will carry on that legacy of discovery into the middle of this century and beyond.

6. The ICRP recommended that for JWST, a conservative cost and schedule confidence level of 80 percent, rather than the NASA policy of 70 percent, should be followed. Does NASA have guidelines for determining whether a mission should be budgeted at a 70 or 80 percent-integrated cost and schedule confidence level? If so, what are those guidelines?

Response: Yes. NPR 7120.5 has been revised to direct that managers shall plan and budget programs and projects based on a 70 percent joint cost and schedule confidence level (JCL) or as approved by the Associate Administrator. Any joint confidence level approved by the Decision Authority at less than 70 percent must be justified and documented (as was done in the case of JWST). NASA carefully considers risks and external and independent advice when deciding the confidence level and may increase the level to a level, such as 80 percent, when appropriate.

From Representative Jerry Costello

1. What mechanisms has NASA put in place to ensure that the JWST program remains on track for launch in 2018, and what information will Congress need to be able to verify that those milestones are being achieved?

Response: NASA has implemented all the recommendations of the Independent Comprehensive Review Panel report, as we described to the Congress in our report submitted on April 21, 2011. These include: restructuring of JWST program management at NASA Headquarters and establishment of a JWST Executive Committee of senior government and contractor executives that meets quarterly; establishment of a strong system engineering capability on the government side with close collaboration with the prime contractor; and establishment of a cost and schedule baseline with adequate reserves in each year of development and account of liens and threats; strong independent reviews at key points in the development to verify that the project is making progress per its plan and to offer additional insights based on the independent review teams experience; and, regular reviews with senior NASA management to assure that project concerns are addressed quickly to avoid cost and schedule implications. The JWST Program Office at Headquarters and the Project Office at NASA Goddard Space Flight Center closely tracked progress on an identified set of program milestones for 2011 and all but one was completed. The same is being done now for 2012, and the list of FY 2012 milestones is shown in the table below.

JWST Planned FY 2012 Milestones

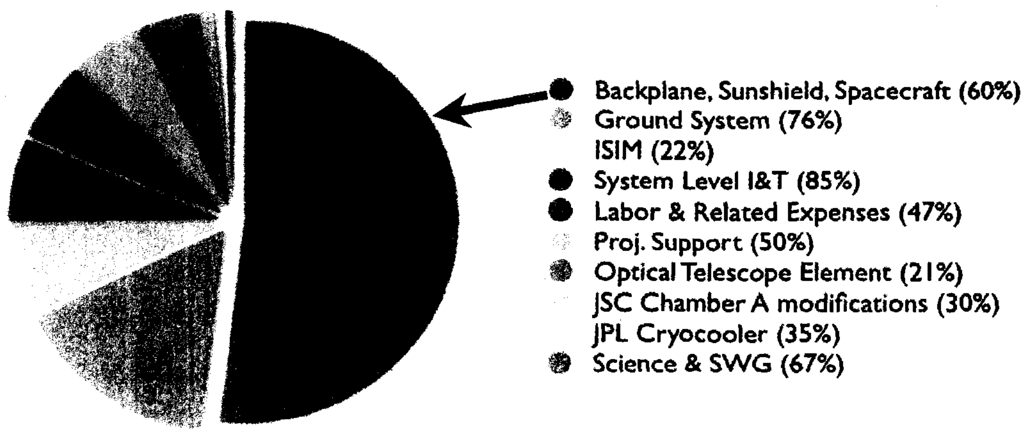
Month	Milestone	Comments
Oct '11	Begin construction of 140,000-lb robotic facility to build segmented main mirror at GSFC	Assembly began 10/4
Nov '11	Complete electronics simulator model for Integrated Science Instrument Module ("ISIM")	Completed 11/15
	Deliver tools for software development environment and verification	Completed 10/27
Dec '11	Install Helium shroud floor at Johnson Space Center thermal vacuum chamber ("JSC TVC")	Completed 10/26
	Determine root cause of NIRSpec optical bench flaw	Completed 12/15
Jan '12	Conduct Critical Design Review for Spacecraft-to-Optical Telescope Element vibration isolation system	Completed 12/15
	Finish building Center of Curvature Optical Assembly ("COCOA") for testing primary mirror in JSC TVC	Completed 1/13
	Review preliminary requirements for ground structure for spacecraft equipment panels	Completed 12/1
	Complete Aft Optic System integration and alignment	Completed 12/2
	Update Program Plan and Program Commitment Agreement to reflect replan	Completed 1/28
Feb '12	Complete assembly and initial testing of main mirrors at Marshall Space Flight Center	Completed 12/19
	Install Helium shroud walls at JSC TVC	
Mar '12	Complete assessment of System Engineering Team thermal margins	
	Deliver ISIM computer #2 to ISIM integration and testing	
	Complete analysis of JSC TVC telescope testing equipment plans	

Apr '12	Receive Flight Mid-infrared Instrument (MIRI) from Europe, first of the telescope's four science instruments	
	Complete Critical Design Review for Sunshield Support Structure	
	Complete all composite parts for mechanism that lifts telescope away from spacecraft after launch (Deployable Tower Assembly)	
May'12	Finish testing the COCOA	
	Measure Sunshield template layer 5 shape to confirm its accuracy	
	Conduct budgetary and schedule review of initial program and project performance since completing the 2011 replan	
Jun '12	Complete modifications of JSC TVC	
	Complete Critical Design Review for telescope-ground communications system	
	Complete designs for structures that will hold telescope inside JSC TVC	
	Complete Preliminary Design Review for equipment that tests Sunshield deployment	
Jul '12	Reach agreement with Program Office on FY13 spending plan	
	Deliver Flight Fine Guidance Sensor	
	Deliver flight software to ISIM Integration and Testing ("ISIM I & T")	
	Complete Solar array Preliminary Design Audit	
	Deliver MIRI Cryo Cooler "Cold Head Assembly" (critical component of MIRI cooling) to ISIM I&T	Flight CHA to be delivered in June 2013. No impact, work around in place.
	Complete fabrication of end fitting for Secondary Mirror Support Structure	
Aug '12	Order remaining JSC thermal vacuum chamber vibration isolators	
Sep '12	Deliver NIRCam, the second of the telescope's four science instruments	
	Deliver telescope simulator for ISIM I&T	
	Start testing of cryogenic camera system, used for subsequent JSC I & T	
	Complete center section of Backplane Support Structure for main mirror	
	Deliver NIRSpec, the third of the telescope's four science instruments	Delivery date moved to 2/13. No impact to, work around in place.

Blue indicates milestones completed ahead of schedule.

Finally, the following chart displays a percentage breakout by cost of major activities of the work yet to be completed on JWST, from FY 2012 through launch and commissioning (i.e., up to the beginning of science operations).

Work-to-Go (FY 2012 through launch and commissioning)



Relative Proportion of Project Funding to Go Element **Percentage Work to Go by Project**

NASA will keep the Congress informed of progress on these milestones and work to go.

2. You have indicated that one of your concerns with the replan's launch date of 2018 is the need for the JWST team to remain focused and motivated to keep the momentum of this year. What is your plan for ensuring that the team stays focused and motivated?

Response: One of the key means to keep the JWST Team focused and motivated is good internal communication. The Project Office meets with the senior staff weekly and with the entire project staff monthly to ensure all information about the project (whether good or bad) is made available. Secondly, the team is very aware of the importance of JWST to not only NASA, but to the Nation and understands the importance of their individual contributions. The budget and stability of the budget provided for JWST makes this new mission baseline executable and allows the project to "do what we say we are going to do." Success in meeting commitments is very positive feedback to a team and keeps it focused on the future. Finally, the delivery of hardware is always a large motivator and builds excitement. During the past year, hardware has begun to arrive at the Integration and Test Facility at NASA/GSFC. During the coming year, science instruments will be delivered and the build up and testing of the instrument module will begin. In addition, many of our contractors now have various components of flight hardware at their facilities (e.g., completion of all telescope mirrors). The entire project is transitioning into the Integration and Test Phase. This is a time of great excitement and keeps everyone focused and motivated.

3. The ICRP report noted that "*A decision on system engineering is a decision on accountability. In a project of this complexity and visibility, it is appropriate for the Government to be accountable. It is crucial, however, that the transfer of responsibility be executed properly.*"
    a. What has been the impact of moving systems engineering accountability from Northrop Grumman to NASA? How did that transfer go?

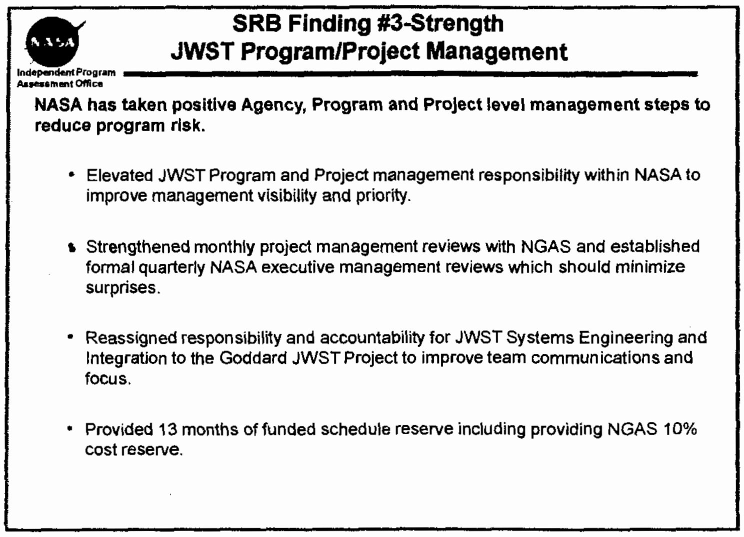
Response: The primary impact of the transition of systems engineering is a more streamlined team in which management of systems interfaces is better aligned with responsibilities. This reduces inefficiencies and risks associated with cross-organizational boundaries. It also reduces the time to make decisions to address system optimization as opposed to segment and element optimization.

The government has responsibility for providing the Launch Vehicle, the Ground Segment, and the Integrated Science Instrument Module. It also has responsibility for the Johnson Space Center and Goddard Space Flight Center (GSFC) test facilities both of which play significant roles in the system level test and verification programs. Decisions involving allocations and interfaces between these segments and the prime contractor provided portions of the observatory have been areas of particular complexity. Negotiations of these interfaces had to cross-corporate and multi-national boundaries. Issues regarding ITAR, and corporate intellectual property were often obstacles that prolonged these efforts. Having GSFC lead the system engineering team responsible for these negotiations improves efficiency as well as minimizes the risks the dropout of critical information introduced by these boundaries.

Overall the transfer of the responsibility of the leadership of system engineering from the prime contractor to GSFC has gone well. There were no significant personnel or organizational issues. Soon after this transfer benefits of the new organization began to be realized. The prime contractor system engineers began to surface and address technical problems, which had long been suspected by the GSFC technical team. The new organization fostered an environment where identifying and addressing technical problems as part of an open, non-organization-centric team was encouraged. Had these problems lingered, the costs of fixing them could have been much higher. The current thermal margin recovery efforts as well as the successful efforts to fix the Star Tracker Assembly mount roll stability are prime examples of this.

b. Has this transition process been examined given its importance to the program? If so, by whom and what were the findings?

Response: The JWST Standing Review Board (SRB) examined the transition of system engineering leadership. Key members of the SRB were present and audited various working meetings that occurred as part of this transition process, among them the working meeting at the JWST Partners Workshop in Houston TX in January 2011. Formal presentations of the transition were made to the SRB during their review of JWST that occurred on March 31, 2011 and May 10, 2011 at the GSFC. The SRB reported their findings to the NASA Science Mission Directorate on June 16, 2011. Finding #3 of their report cited the reassigning of responsibility and accountability for JWST Systems Engineering and Integration to the Goddard JWST Project to improve team communications and focus as a strength. The chart below is an excerpt from that presentation.



Chairman Ralph M. Hall

March 7, 2012 Hearing
on
An overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2012

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1. **In July or August NASA's commercial crew program *[known as the Commercial Crew Integrated Capability i.e. CCiCap]* plans to give $300 to $500M to multiple companies using Space Act Agreements instead of more typical government contracts. According to NASA's Office of General Counsel, Space Act Agreements do not permit NASA to impose design or safety requirements on the contractors.**

    a. **How can we be assured that NASA is developing safe systems if it is prohibited from levying any requirements, or demanding performance tests from the companies?**

ANSWER: In order to ensure safety is not compromised for the Commercial Crew Program, NASA plans to transition to a Federal Acquisition Regulation (FAR)-based contract for certification of commercial systems prior to flying crew on these systems. NASA intends to structure the certification phase following the Commercial Crew Integrated Capability (CCiCap) effort to permit the Agency to fully evaluate the proposed systems and accommodate any necessary redesign to ensure compliance with NASA safety, performance, and mission success requirements. The provider(s) awarded a certification contract will not only be required to meet the NASA requirements in order to fly NASA personnel, but they will also have to show verified compliance of how the design and hardware will meet these requirements. Thus, there will be no reduction in the safety expectations or requirements as a result of this change in acquisition strategy.

NASA believes that it is implementing the best strategy for commercial crew that will maximize the taxpayer investment without compromising safety by using Space Act Agreements (SAA) in this next phase. First, NASA has released the baseline set of safety, performance, and mission success requirements to all of industry. NASA also has made these requirements available to all providers as reference under the CCiCap effort. Although compliance with these requirements is optional for industry under a funded SAA, NASA anticipates that providers will use the NASA requirements to inform their development activities, thereby reducing the technical risk associated with the lack of NASA oversight under an SAA. Second, because NASA plans to have two to three companies involved in the next phase of SAAs, we believe the competitive environment provides strong incentive for the companies to align with NASA's certification requirements in order to remain competitive in the future certification and services phases.

Third, NASA included an "Overall Safety Goal" in the CCiCap Announcement for Proposals (see page 3 of the Announcement) which states:

> "Successful commercial human space flight demands the highest commitment to safety; therefore NASA has the goal of fostering a safety culture in the commercial space flight industry that ultimately will minimize the risks associated with human space flight to LEO. NASA's goal is for Participants to demonstrate safety processes that include strong inline checks and balances, healthy tension between responsible organizations, value-added independent assessments and appropriate data archival, which will increase Government confidence in the Participant's approach to safety."

As a result, NASA will have full insight into the providers' approach to safety during CCiCap as the providers meet their milestones associated with the CCiCap agreements.

b. What recourse does the government have if these companies fail to perform or go out of business?

ANSWER: Under the CCiCap Space Act Agreements (SAAs), NASA is entitled to terminate an SAA if a provider misses a milestone and NASA determines that additional efforts are not in the best interests of the parties. NASA would consult with the provider prior to exercising this termination. If NASA terminates an agreement for the partner's failure to perform, NASA is entitled to exercise Government purpose rights in any technical data or inventions developed under the agreement. This allows NASA to use the data or inventions to continue the activity by or for the Government. Competition and having multiple providers is important in this overall strategy. If one company is unsuccessful, we can terminate and continue work with the others and still achieve our goals. In the unlikely event that all parties fail, then NASA could continue to purchase Soyuz seats for crew transportation and rescue purposes, as the Agency will have been doing for several years, assuming appropriate INKSNA relief and pending sufficient contracting lead time.

c. What, if anything, will NASA own after making these expenditures?

ANSWER: A principal goal of CCiCap is to "seek and encourage the fullest commercial use of space," a stated purpose of NASA under the National Aeronautics and Space Act of 1958 (the "Space Act"), as amended. In order to foster such commercial use, participants in CCiCap retain maximum Intellectual Property (IP) rights permitted by law.

NASA does not obtain rights to use our partner's proprietary data unless special circumstances arise, such as termination of the SAA for the partner's default or our partner's failure to make commercial use of the technology developed under the SAA. NASA retains "government purpose" rights in reported inventions owned by the Participant as required under the Space Act. NASA has agreed not to exercise its "government purpose" rights for five years after the end of the SAA. NASA's ability to exercise its government purpose rights in inventions is accelerated in the event of the participant's default. This means that the data and inventions can be used by or on behalf of NASA in future development efforts.

NASA has determined that title to all tangible property acquired by the participant under the CCiCap Agreement will remain with the participant(s). Unlike a procurement contract, the purpose of a funded Space Act Agreement is not to obtain property for NASA. Instead, it is to stimulate the Commercial Partner's efforts. However, NASA reserves the right to acquire any tangible personal property acquired or developed under the SAA from the SAA partner, taking into account the amount NASA has already contributed under the Agreement. The specific terms applicable to data, inventions and personal property can be found in the model SAA attached to the CCiCap Announcement: http://prod.nais.nasa.gov/cgi-bin/eps/sol.cgi?acqid=149848.

2. **NASA officials have asserted that if the FY2013 request of $830M for commercial crew is not fully funded for each of the next five years, the program's ability to begin routine flights in 2017 will be jeopardized, possibly for several years. Given the current fiscal environment, NASA may find it advantageous to, reduce the number of contracts down to one or two firms. This would allow the agency to use a standard acquisition contract that would permit them to put safety requirements in place, and allow the agency to implement stricter insight/oversight. Why not down-select now and put one or two companies under contract, and avoid the uncertainties and possible wasted investment of carrying unsuccessful bidders through the upcoming phase?**

ANSWER: NASA believes that having multiple companies competing against each other at this stage of the Commercial Crew Program will result in lower overall costs for the Government and will help enable voluntary adherence to safety requirements. In a traditional program with a single prime contractor from the start using a cost-plus contract, the NASA-Air Force Cost Model (NAFCOM) cost estimates are approximately $8-11B for the development of an ISS crew transportation capability. Using the current, innovative approach of competing Space Act Agreements will result in multiple awards to industry with fixed Government costs. NASA estimates being able to cut the development costs substantially and to deliver an ISS capability for around $5B. Maintaining competition is a key factor in achieving these savings.

While the Agency has not established a specific number of awardees for the next phase of the Commercial Crew Program, referred to as CCiCap, NASA is planning to have fewer funded companies in CCiCap than are currently participating in CCDev2. There are 7 partners in CCDev2 (4 funded and 3 unfunded partners). NASA would like to maintain as much competition as it can for as long as possible.

Removing competition by developing a single system from various companies' system elements would eliminate most of the commercial aspects of the program. With only one provider from which NASA could purchase services, there would be little incentive for the companies to expand their commercial market base by selling services to any other customers or to maintain reasonable prices. There would also be no incentive for the companies to share in the development costs. Having industry share in the cost of development and selling seats to other customers in addition to NASA will likely decrease NASA's costs for crew transportation services in both the short and long-term.

3. **Now that the life of the International Space Station has been extended to 2020, does NASA anticipate negotiating new barter arrangements with our international**

partners to extend their cargo service agreements?

ANSWER: Yes, NASA is conducting barter discussions with our international partners to enable the continuing offset of their respective ISS common system operations cost obligations through 2020.

a. **How do NASA and the international partners plan to supply and maintain the ISS?**

ANSWER: The ISS Partnership continues to employ the successful mixed fleet strategy to supply and maintain the ISS. This fleet includes proven transportation vehicles from Russia, Europe and Japan, as well as services that will be provided by Orbital Sciences Corporation (OSC) and Space Exploration Technologies (SpaceX) under the Commercial Resupply Services contracts. These U.S. commercial vehicles are scheduled to be demonstrated this year.

b. **How many total future cargo flights have the Europeans and Japanese committed to?**

ANSWER: In payment of their ISS Common System Operations Costs obligations through 2015, the European Space Agency (ESA) committed to provide five Automated Transfer Vehicle (ATV) flights through 2014 and the Japan Aerospace Exploration Agency (JAXA) committed to seven H-II Transfer Vehicle (HTV) flights through 2016. To date, three ATVs have been provided (including ATV-3 currently on orbit) and two HTVs have been provided (HTV-3 is scheduled for launch on July 21, 2012).

c. **What is NASA's plan to supply and maintain the ISS if the commercial providers continue to experience delays, or are unavailable or out of business?**

ANSWER: There is sufficient margin in logistics, consumables and systems spares through early 2013, to protect ISS operations for a delay in the start of commercial cargo delivery. Commercial Resupply Services (CRS) flights will augment existing resupply capability needed to support the crew on-orbit. Those needs continue to be met through the ESA-provided ATV, the Roscosmos-provided Progress and Soyuz, and JAXA-provided HTV vehicles now that the Space Shuttle has been retired. The U.S. commercial providers are in the process of bringing their vehicles on-line to provide the needed resupply capability. Recognizing the challenges of initial flights and bringing a new vehicle into operations, NASA and its international ISS partners previously delivered additional supplies to accommodate potential slips to the CRS schedule. The commercial strategy does not rely on a single flight or provider. On May 22, 2012, SpaceX launched its second COTS demonstration flight, and three days later, the Dragon spacecraft was berthed to the ISS. The mission, which accomplished the remaining COTS demonstration goals for Space X, was brought to a successful conclusion on May 31, with the deorbiting and splashdown of the Dragon capsule.

4. **The FAA is responsible for licensing commercial launches. Yet, the recently passed FAA reauthorization *prohibits* the FAA from regulating "the design or**

operation of a launch vehicle to protect the health and safety of crew and space flight participants," until at least October 1, 2015.

a. Which agency is responsible for regulating the safety of the astronaut crews?

ANSWER: Although it is not a regulatory Federal Agency, NASA is responsible for ensuring the safety of NASA crews/workforce and assets during NASA or NASA-sponsored space operations. In addition, NASA retains responsibility for public safety during launch and reentry operations if those operations are not FAA-licensed. In support of those responsibilities, NASA is currently developing the certification requirements and program processes for commercial transportation of NASA crews to the ISS.

At some time in the future, both NASA and the Federal Aviation Administration (FAA) envision a scenario where the FAA licenses commercial human spaceflights provided by a robust industry, from which NASA and the private sector can purchase transportation services. The FAA has already developed processes and procedures for licensing and regulating commercial space activities to protect the safety of the public. Additional regulations for the protection of crew safety are in development, pending Congressional authority for the FAA to propose crew and spaceflight participant safety regulations.

b. Which agency is responsible for regulating the safety of astronauts on commercial sub-orbital flights funded by NASA? Could you please describe how you are working with the FAA to ensure their ability to verify a vehicle is safe?

ANSWER: NASA is currently only funding research payloads using suborbital providers. Flying astronauts is not part of the current programming for suborbital flights funded by NASA.

NASA has agreements with seven different suborbital flight providers to allow for purchase of flight services for research and development payloads. Of these providers, only two are flown by pilots and constructed to carry passengers (Virgin Galactic and XCor Aerospace). At this time, NASA has no plans to use commercial suborbital flight providers to fly astronauts, civil servants or NASA-funded researchers.

Like all developmental and experimental aircraft, the flight providers are putting their vehicles through a rigorous testing profile with continuous improvements until they are capable of achieving the desired altitude and vehicle performance outcomes.

NASA requires the suborbital providers under contract to obtain approval from the FAA or other governing authority for the flight activity. Launch vehicles that fall under jurisdiction of FAA Office of Commercial Space Transportation are normally required to be licensed. NASA collaborates with the FAA in payload reviews and flight scheduling, but the licensing process remains between the flight provider and the FAA. In addition, NASA and the FAA remain in regular communications about the progress of the flight providers.

5. **For NASA's first manned mission beyond low Earth orbit, agency officials have**

stated that lunar fly-bys, asteroid missions, and missions to a LaGrange Point are under consideration. What steps is NASA taking to develop a habitation module and/or a service module to sustain the crew on a long-duration mission? What is the *next* hardware development that NASA is planning beyond SLS and MPCV?

ANSWER: The Deep Space Habitation project was started in the Advanced Exploration Systems (AES) Program in FY 2012. This project is developing system requirements and concepts for habitats, and demonstrating habitat mockups in ground-based tests. In parallel, the AES Program, in partnership with the Game Changing Development (GCD) program under Space Technology, is developing technologies for highly-reliable, next generation life support systems, radiation monitoring and protection, advanced space power systems, fire safety, logistics reduction, and autonomous mission operations that will be incorporated into a habitat mockup around 2015 for integrated testing. The AES Program is also pursuing a commercial partnership to demonstrate an inflatable module on the ISS. ISS is being used to look at life support systems as well as many components of the new systems.

- **What international contributions are assumed for long-duration missions?**

ANSWER: NASA has continued to build and strengthen international partnerships to meet the greater challenges of human exploration including future long duration missions. In addition to the on-going research being conducted on the International Space Station (ISS), partnership discussions are underway to explore how the ISS can be most effectively used as a test-bed for long duration missions. In parallel, the International Space Exploration Coordination Group (ISECG) space agencies are coordinating an international effort to define technically feasible, programmatically implementable, and sustainable exploration pathways beyond low-Earth orbit (LEO). As a result, significant progress has been made and there is now a consensus among NASA and the participating ISECG agencies that the next steps for human exploration is sending humans sustainably beyond LEO to destinations in cis-lunar space, such as near-Earth asteroids, the Moon, the moons of Mars, and eventually Mars. Specific international cooperation with NASA in its beyond-LEO exploration architecture will be defined as NASA's human space exploration strategic planning and analysis advance, and specific near-term opportunities for international contributions to the SLS and Orion MPCV, as well as technology demonstrations and robotic missions will be explored as these programs develop.

6. **The current budget request indicates that Mars exploration is not a priority for this Administration despite the stated goals of a human mission to Mars in the 2030s.**
    - **Without robotic precursor missions that include sample return, is Mars really a planned destination? Does NASA anticipate omitting a sample return mission prior to putting astronauts on the surface of Mars or one of its moons?**

ANSWER: While the current fiscal climate required us to make tough choices, it also presented an opportunity to reformulate a Mars program optimized to further the nation's and NASA's goals in scientific discovery, human space exploration, and technological innovation. Within constrained budgets, coordinating these activities makes sense. These goals include the return of samples from the Martian surface, and the enabling of human expeditions to Mars in the 2030s.

NASA is working on a new architecture for Mars exploration aimed at both of these goals, beginning with definition of a mission concept to take advantage of the favorable 2018 or 2020 launch windows within available resources.

7. Some of NASA's most productive and exciting science missions have been flagships, examples being Hubble Space Telescope, Cassini mission to Saturn, Galileo mission to Jupiter, and the Mars Science Laboratory. Why has NASA chosen to abandon this highly successful class of missions? The normal development cycle for a flagship mission often takes a decade or more. When does NASA plan to begin planning and formulation of a future flagship mission?

ANSWER: NASA has not abandoned this class of mission, as evidenced by our continuing development of the James Webb Space Telescope. NASA plans a balance among missions driven by science objectives. Flagship missions provide the capability to answer the most challenging science questions and serve to advance research by the largest fraction of the scientific community. Moderate and small missions address unique, exploratory science questions, often through Principal Investigator-led missions that enhance the experience of the science community in space mission design and implementation. Discoveries from some of these smaller missions will likely inform and shape future large flagship missions. Currently, budgetary resources do not afford the pursuit of more than one flagship-scale science mission at a time in a balanced science program. Thus, NASA's budget request for FY 2013 does not initiate any new flagship-class mission. A future determination to initiate a flagship-class mission will be driven by science and exploration objectives and resource availability.

Ranking Member Eddie Bernice Johnson

March 7, 2012 Hearing
on
An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2013

1. **In all prior communication, including your message accompanying the budget justification, NASA has defined its agency priorities as (1) SLS and MPCV for exploration, (2) enhancement of the ISS supported by a robust commercial crew and cargo program, and (3) JWST. Yet, in your written testimony, you now add a fourth priority, space technology. Please explain why you have redefined NASA's priorities.**

ANSWER: Space Technology is and has been a priority for NASA, as evidenced by the initiation of the separate Space Technology program in 2011 and our request for increased Space Technology funding in 2012 and 2013.. Space Technology is not an end, in and of itself; however it is absolutely critical element of NASA's strategy for achieving the Agency's scientific and exploration goals. Space Technology can also result in benefits to other government and commercial space programs and to life on Earth. The underlying importance of Space Technology, as reflected NASA's budget request has not changed. As the President said when laying out the Administration's broader exploration goals for deep space exploration:

"At the same time, after decades of neglect, we will increase investment -- right away -- in other groundbreaking technologies that will allow astronauts to reach space sooner and more often, to travel farther and faster for less cost, and to live and work in space for longer periods of time more safely."

NASA has remained consistently committed to this vision.

2. **Given the slips in the schedules for both commercial cargo and commercial crew operational capabilities and the recent difficulties with the Russian Soyuz vehicles, why is the Administration unwilling to request funding and support for developing the capability for the MPCV and SLS to serve as backup transportation to low Earth orbit, as NASA was directed to do by law? Does NASA consider the risk of commercial services being unavailable by 2017 to be low? How much additional funding would be required, and what is the basis for that estimate?**

ANSWER: NASA believes that commercial crew transportation systems could be available to provide services to the Agency and other customers by the middle part of the decade. Given reasonable funding levels, NASA is planning for commercial crew capability to be in place in 2017; but these plans will not preclude earlier availability of services.

NASA plans to rely on U.S. commercial providers for the delivery of cargo and crew to ISS. The Orion MPCV and SLS could be used as a back-up system for transportation to and from the

ISS, but this would be a very inefficient use of vehicles that are being designed and developed for deep-space missions.

The 2017 date of the uncrewed SLS/MPCV test mission is driven primarily by technical development schedules, not funding, and NASA is working to develop these vehicles as rapidly as possible, in part through the use of existing contracts. NASA is currently conducting an integrated technical, schedule, and cost review, which will be completed late this summer. The results of this review will help NASA assess whether it might be possible to accelerate the crewed SLS/Orion MPCV test mission, currently scheduled for 2021.

SLS/MPCV Orion is uniquely designed for deep space travel and will be extremely costly to use for low Earth orbit activities. The Commercial Crew Program is the best way to develop crew transportation to the ISS.

3. **Congress has established the policy that the U.S. will support ISS utilization and operations through at least 2020.**

   a. **What is NASA doing to prepare for a decision on whether to support the ISS beyond 2020?**

ANSWER: The lifetime extension data that NASA and the ISS Partnership have reviewed to date indicates that extension to 2028 is technically feasible. The analysis and certification, once completed, will determine the ISS structural hardware's ability to operate safely through 2028.

In addition, current spares procurements and planned procurements assume ISS life at least through 2020. The date for determining which spares are required to support beyond 2020 is reassessed each year assuming the updated Mean Time Between Failure (MTBF) numbers. Based on past performance, many of the spares procurements should support ISS beyond 2020, but if specific additional spares are required to extend ISS beyond 2020, the procurements should be on contract by 2017.

   b. **When does that decision need to be made?**

ANSWER: The decision to extend ISS Operations beyond 2020 will need to be made well before 2020 to enable a smooth continuation of the program. If the ISS is going to be extended, NASA would prefer to have procurements in place by the end of FY 2017 for crew seats, logistics vehicles, consumables, and possibly some spare components. An early decision point also attracts and better supports ISS research and utilization customers that will be planning to wind down their efforts in preparation of ISS deorbit in 2020.

4. **You indicate that NASA will be requesting modification to its waiver of the Iran, North Korea, Syria, Nonproliferation Act (INKSNA) which lapses in July 2016. What time period for the waiver will you be requesting? When can Congress expect to receive the request?**

ANSWER: Some modification of the Iran, North Korea, Syria Non-proliferation Act (INKSNA) provisions will likely be required for the continued operation of ISS and other space programs after 2016. The Administration plans to propose appropriate provisions and looks forward to working with the Congress on their enactment.

5. **As you mentioned in your prepared statement, NASA will no longer participate with the European Space Agency in previously agreed to collaborative Mars missions in 2016 and 2018 and is initiating an analysis of how it can implement an integrated strategy for long-term human and robotic exploration of Mars.**

   a. **How is NASA addressing the loss of U.S. leadership and critical capability in landing and operating spacecraft on the surface of Mars, a technical skill that no other nation currently possesses?**

ANSWER: NASA is working to reformulate a Mars program optimized to further the nation's and NASA's goals in scientific discovery, human space exploration, and technological innovation. These goals include the return of samples from the Martian surface, and the enabling of human expeditions to Mars in the 2030s. NASA is working on a new architecture for Mars exploration aimed at these goals, including the definition of a mission concept to take advantage of the favorable 2018 or 2020 launch windows within available resources. We plan to have this initial architecture ready this summer. Landing large masses on the Martian surface remains a necessary part of any strategy for Mars exploration. Therefore, while a loss of some skilled personnel after the landing of MSL is likely, NASA will work to retain critical skills and capabilities sufficient to enable the necessary surge in our entry, descent, and landing capacity prior to the next landed mission to Mars, thus retaining our leadership in the exploration of the Red Planet.

   b. **How do you propose to deal with the perception by the international space community that the U.S. is an unreliable partner, thus damaging future opportunities for international collaborations?**

ANSWER: NASA has a long history of very successful cooperation with nations around the world, and a part of that history has from time to time included some decisions by NASA and some by our international partners to re-phase or redesign or even terminate planned cooperative activities. Our partners are very aware that in all instances our cooperation is based on the availability of appropriated funds, just as we are aware that their participation has similar funding constraints. Consistent with the National Space Policy and the Space Act, NASA will continue to pursue international cooperation in support of its activities and mutual objectives. Currently, NASA has over 500 active agreements with over 100 countries and anticipates that international cooperation will remain a cornerstone of all of its future activities.

6. **Has NASA identified the specific path forward for its human exploration program, including intermediate objectives, destinations, and options for human exploration that maximize the productive use of MPCV and SLS as soon they become available, and if not, what is preventing you from doing so?**

ANSWER: NASA's ultimate destination for human exploration is Mars. Consistent with policy and law, NASA is planning an asteroid mission as the first part of a capability driven approach to explore multiple deep space destinations. Mission analysis and international discussions supporting these efforts are ongoing. NASA will ramp up our capabilities to reach -- and operate at -- a series of increasingly demanding targets, while advancing our technological capabilities with each step forward. This will include early test and demonstration activities in cis-lunar space as called for in the NASA Authorization Act of 2010. Along these lines, we will fully tap the potential of the ISS. We will also conduct a series of test and demonstration flights. For example, we plan test flights of an uncrewed Orion spacecraft in 2014 and of the SLS in 2017, followed by a crewed mission in 2021 as part of developing the foundation for our longer journeys. NASA's Orion and SLS will enable the Agency to send astronauts beyond LEO for the first time since 1972 and will provide the nation a capability and architecture designed to also allow flexibility, partnering and technological on-ramps. This approach provides a path for a sustainable program to extend human presence into the solar system.

Congressman Dana Rohrabacher

March 7, 2012 Hearing
on
An Overview of the National Aeronautics and Space Administration
Budget for Fiscal Year 2013

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1. **NASA has $229.3M requested for the ISS Research line item. Parts of these funds are used for Multi-user System Support (MUSS). MUSS provides strategic, tactical, and operational support to all the NASA sponsored payloads and non-NASA sponsored payloads, including five international partner research payloads. This includes maintenance and operation of the ISS research infrastructure, including research integration, payload engineering, integration, and operations; payload systems support etc.**

   - **What percentage of the ISS Research request for FY 2013 will be spent for Multi-User System Support, and what percentage will be spent for pure grant opportunities?**

ANSWER: The budget for Multi-User System Support (MUSS) in FY 2013 is $154M, or 67 percent of the total ISS Research budget of $229M. The Non-Profit Organization (NPO) budget is $15M, or 7 percent of the total ISS Research budget. The biological and physical research budget is $60.3M, or 26 percent of the ISS Research budget (approximately $15M is directly awarded for grants). However, the remaining funds also support grants through hardware development and other activities required by grantees to conduct their research on ISS.

- **What else does "ISS Research" encompass?**

ANSWER: ISS Research is primarily broken into the three major categories listed above: MUSS, NPO, and biological and physical research.

- **What percentage of the ISS research capability is NASA utilizing? What percentage remains unused?**

ANSWER: At the rack level, 78 percent of the ISS research locations contain a payload rack (18.25 racks of the 23.25 rack capacity, not including 0.75 rack used for systems). NASA research outfitting of rack-level facilities is complete, with other rack space being used for payload stowage.

At the sub rack level, averaged across the capacity of each rack, the overall sub-rack volume utilization is 72.5 percent (as of the end of FY 2012). This includes several different types of racks. Some racks are fully occupied with equipment for the science objectives. Such equipment may be in either continuous or occasional use due to the nature of the science supported. Some racks that can support multiple runs of experiments for a discipline could support more throughput than is currently being done. Some multipurpose EXPRESS racks are only partially occupied with scientific experiments, providing capacity for future users. For EXPRESS racks alone, the occupancy at the end of FY 2012 will be 62 percent.

Resources for using the pressurized volume support the current throughput with the ability to support growth in future up mass and down mass. Crew time is currently 100 percent subscribed.

NASA has rights to 15 external payload sites. Currently, 6 sites are occupied, with 1 additional payload to be added on the next HTV flight. The occupancy for external sites at the end of FY 2012 will be 47 percent.

- **Why is the MUSS function included in the ISS research funding line, rather than in ISS operations?**

ANSWER: MUSS is basically the Operations and Maintenance (O&M) function related to research on ISS. While it is currently booked under ISS Research, it could alternatively be reported as part of ISS Systems Operations and Maintenance, since it is O&M work. It is being reported in ISS Research because historically it has been reported as part of ISS Research.

2. **NASA is requesting funds to restart Plutonium-238 production to power deep space missions, but there is no corresponding request at the Department of Energy, which would need to produce the Pu-238.**

- **Is Plutonium-238 production restarting?**

ANSWER: DoE has started the project definition phase of the Pu-238 restart effort. This assessment is necessary to understand how facilities can be used to begin the production of Pu-238. We expect that the study will be complete by the end of calendar year 2013. At the end of project definition phase, we will have a better estimate of the schedule and cost to re-establish Pu-238 production.

- **Is NASA expecting to cover all of the relevant costs moving forward?**

ANSWER: NASA is funding all the costs of conducting the current project definition phase assessment (i.e., through FY 2013). How to apportion costs between the agencies will be the subject of future discussions between DOE and NASA and will inform future budget requests.

Congressman Randy Neugebauer

March 7, 2012 Hearing
on
An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2013

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1. **Administrator Bolden, in recent years NASA has experienced numerous issues of cost overruns and missed deadlines. As you well know, the United States' $15 trillion debt necessitates major cuts in spending and tighter budgets. As a result, accurate cost projections and strict adherence to timelines are crucial to keeping spending under control and ensuring that important projects are able to continue receiving funds each year. What assurance can you provide in the current timelines and budgets for Commercial Crew, SLS, MPCV, and the James Webb Space telescope? What makes current projections more reliable than previous ones and what is NASA doing to ensure that programs come in under cost and before the projected timelines?**

ANSWER: NASA recognizes the critical importance of improving cost and schedule performance of our one-of-a-kind Research and Development projects.

In cost management as in technical challenges, we learn from our successes and failures and adjust to improve our performance. In recent years, NASA has implemented a series of new policies and approaches for improving cost performance. These include:

- Establishment of Key Decision Points which serve as formal gateway review through which missions must pass to proceed to the next stage;
- Establishment of Life Cycle Cost targets based on probabilistic independent cost estimates;
- Establishment of Joint Confidence Levels to determine those targets based on integrated cost and schedule analyses
- Monitoring of cost and schedule performance with independent assessments of Earned Value (work accomplished compared to resources expended).

These changes are benefiting projects currently in development, and projects initiated after these measures were put in place will benefit the most. Cost performance for recent missions has improved. In 2011, we launched Juno, a planetary science mission to Jupiter. This billion-dollar mission launched on time and within budget. GRAIL, a twin-spacecraft, half-billion dollar mission to study the moon, completed its development at seven percent under the Agency's cost estimate.

The Orion MPCV and SLS programs are developing detailed estimates this year as part of the Agency's budget development process. However, NASA is developing this capability under a flat-line budget as reflected in the President's Request. These estimates will build upon the initial cost estimates the programs developed last summer in support of the announced

Exploration architecture. As part of this process, an external party conducted an Independent Cost Assessment that was used to help inform and reinforce NASA's budget planning estimates. Both of these programs are using heritage systems to minimize development risk, holding a tight requirements focus, and being implemented in a scaled, evolvable manner with a test and flight cadence to drive results. All of these factors have been cited in independent and DOD reports on improvement areas. We have also established an independent "best practices" and assessment group to look at all of NASA's projects and programs.

The FY 2013 budget request for Science includes $627.6M for the James Webb Telescope (JWST). The scientific successor to the Hubble Space Telescope (HST) and the Spitzer Space Telescope, JWST will be used by international teams of astronomers to conduct imaging and spectroscopic observations. The Observatory will be located in an orbit near the second Sun-Earth Lagrange point (L2), approximately 1.5M km from Earth. The telescope and instruments will be operated at a temperature of 40 degrees above absolute zero (40 Kelvin) shielded from the heat of the Sun by a large sunshield, to enable the Observatory to achieve unprecedented sensitivity over its entire wavelength range. Over the past year, NASA has engaged in a thorough review of JWST, made important adjustments to management, and put the project on a sound financial footing. Since we completed this new plan, the project has met 19 of 20 FY 2011 top-level milestones (with one deferred without impact), and has met 19 of 21 FY 2012 milestones through May on or ahead of schedule (the two missed milestones were completed in May without impact. All 18 JWST primary mirror segments have been completed and tested. The first of the four flight instruments was delivered to GSFC on May 29, 2012. NASA expects to take delivery of the remaining three JWST instruments in FY 2012-2013. In FY 2013, NASA will begin sunshield fabrication and continue I&T of the Integrated Science Instrument Module and development of the ground segment. NASA is confident that the FY 2013 request supports a 2018 launch of JWST.

2. **How much money did NASA spend specifically on NextGen research and development in FY 2011, what are the estimates for FY 2012, and what does the Administration expect to spend in FY 2013? Please detail the operational partnership and cost sharing between NASA, the FAA, and any other agencies involved in the development of the NextGen system. How effective has this partnership been, and excluding funding levels what are the potential barriers or delays in deploying the system from NASA's perspective?**

ANSWER: All four of NASA Aeronautics' research programs contribute directly or indirectly to the achievement of NextGen. Airspace Systems Program (ASP) research investments in air traffic management-related concepts and technologies and the Integrated Systems Research Program (ISRP) contributions to advancing technologies needed to support unmanned aircraft systems (UAS) routine access to the National Airspace System (NAS) most directly advance NextGen goals. In FY 2011, $96.6M of the Aeronautics budget contributed directly to the advancement of NextGen in this fashion. In FY 2012, this figure has risen to $122.7M and is projected to be $123.7M in FY 2013 based on the FY 2013 President's Budget. Other NASA research focused on improving the safety of air transportation and enabling new aircraft technologies which improve efficiency, expand mobility choices and reduce the environmental impacts of aviation indirectly contribute to NextGen. Total direct and indirect contributions for each of those fiscal years are $355.7M for FY 2011, $417.8M for FY 2012, and $420.1M for FY 2013.

NASA coordinates closely with the FAA, other Federal agencies and the aerospace industry in planning and executing research to achieve both the near-term improvements in air travel and the longer-term NextGen vision. In addition to working closely with the FAA as a member agency of the Joint Planning and Development Office (JPDO), NASA and the FAA created research transition teams (RTTs) in order to accelerate progress for NextGen advancements in critical areas and effectively transition advanced capabilities to the FAA for certification and implementation. Under RTTs, NASA and FAA develop joint research plans and fund their respective portions of the planned research according to the nature of the research and their relative capabilities. To a limited extent, the FAA provides funding to NASA to perform specific studies or simulations through reimbursable agreements. A recent GAO report (D11604) identified RTTs as a federal best practice for interagency collaboration.

This model for cross-agency collaboration and cost sharing has been very effective, resulting in several recent demonstrations of advanced technology benefits. One such RTT example is NASA's Efficient Descent Advisor (EDA) technology, which will save fuel by enabling more efficient arrivals into congested airports. EDA was developed and field tested through a three-year collaborative effort between NASA, FAA, Boeing, MITRE, Sensis/SAAB, United Airlines and Continental Airlines under a NASA-FAA RTT, and then transferred to the FAA on November 30, 2011, for certification and integration into mid-term (2014-2018) NextGen operations. NASA estimates $300M in fuel savings per year during descents if EDA is implemented fleet-wide at the nation's busiest airports. For this particular effort, the NASA/FAA procurement cost investments were split on a roughly 75/25 basis, not including labor, indirect costs and other in-kind contributions.

NASA transferred the research results from another RTT to the FAA in August 2011 regarding tools and methods for in-flight "flow-based trajectory management" in the NextGen. Joint work continues under two other RTTs, and NASA and the FAA are now building on the RTT model to enhance planning and cooperation in other research areas. Also in 2011, NASA, the FAA, and other federal agencies developed a joint research, technology, and demonstration roadmap for enabling UAS access to the NAS, and strengthened coordination on UAS operational issues through the UAS Executive Committee (EXCOM) that is composed of senior executives from DoD, FAA, DHS, and NASA.

There are a myriad of other coordination activities between NASA and other federal departments and agencies for research directly and indirectly related to NextGen improvements across the entire NASA portfolio. For example, NASA is coordinating with the DoD on aircraft engine improvements through participation on the Steering

Committee for the DoD's Versatile Advanced Affordable Turbine Engine (VAATE) program, and with the FAA in an advisory capacity for the Continuous Lower Energy, Emissions, and Noise (CLEEN) program. NASA research partnerships and coordination also extend to topics such as rotorcraft, subsonic fixed wing aircraft, alternative fuels, aviation safety technologies, and environmentally responsible aviation.

Advances in technologies that address NextGen operational improvements are critical, but several obstacles remain to deployment of broad system-wide improvements. One such area is in the verification and validation (V&V) of complex flight systems. Current techniques for certifying complex systems are inadequate to provide verification and validation of highly automated, non-deterministic software systems, which are expected to be a major component of NextGen. The V&V of complex flight systems was identified as a critical gap to realize NextGen vision by the JPDO, and NASA started its investment for about $20M per year in FY 2011 to address this gap in close coordination with FAA, industry, and academia. Another area that presents a critical gap is the ability to demonstrate system-wide operational concepts. The interoperability of individual technology applications in the NAS cannot be effectively tested or evaluated in anything but the actual NAS, which cannot be readily conducted for safety concerns and other operational issues. Sophisticated system-wide NAS/NextGen simulators need to be developed to enable NextGen technologies to be safely and effectively evaluated for operational benefit and performance.

Congressman Jerry Costello

March 7, 2012 Hearing
on
An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2013

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1. **In response to my question regarding the Administration's primary objective of the Commercial Space Program, you responded that you agreed with the Aerospace Safety Advisory Panel's (ASAP) assessment that a "sea change" had occurred. You also remarked that the FY 2012 budget level meant that *"by default the Congress and the Administration have agreed that we are going to develop a commercial capability for the benefit of the American economy, and it will serve other purposes, but it may not make it in time to serve the International Space Station".***

    a. **Has the White House agreed to the change in the primary objective of the commercial crew program to being one of developing a commercial capability for the benefit of the American economy? Are you seeking an explicit agreement by Congress to the change in objective as part of this year's budget process?**

ANSWER: The objective of the Commercial Crew Program is to facilitate the development of a U.S. commercial human space transportation capability with the goal of achieving safe, reliable, and cost effective access to and from low-Earth orbit (LEO) and the International Space Station (ISS).

This basic objective has remained unchanged since the program was unveiled in the spring of 2010. NASA plans to use commercial capabilities to provide services to ISS once those capabilities have been certified to meet NASA requirements. NASA's strategy is to use Federal-Acquisition-Regulation-(FAR)-based contracts for certification activities. FAR-based contracts will enable NASA to "certify" commercial crew transportation systems for use by NASA for crew transportation and rescue services. Through this process, NASA will ensure that all the necessary NASA safety and performance requirements are met.

    b. **How are you addressing the programmatic risk, which you acknowledged at the hearing, that under the Space Act Agreement approach, you cannot guarantee *"a commercial capability in time to support the International Space Station."***

ANSWER: The programmatic risk of not being able to guarantee a commercial capability in time to support the ISS is not increased because of the use of SAAs. NASA believes the risk could actually decrease because the commercial providers are responsible for determining the best approach to the design and development of their commercial systems which may permit the providers to maintain a rapid pace of technical development.

The risk in developing a commercial system in time to support the ISS is driven primarily by available budgets. NASA's original request for the Commercial Crew Program was:

($ in millions)	2011	2012	2013	2014	2015
FY 2011 BUDGET REQUEST	500	1,400	1,400	1,300	1,200

With the FY 2011 budget request, NASA estimated that a commercial crew capability could be in place by 2015. However, the amount available under the FY 2011 appropriation was $312M ($188M less than requested). Thus, NASA reduced its expected progress and initiated CCDev Round 2, which only matured elements of the systems instead of overall integrated crew transportation systems. The combined impact of the lower than expected budget and having to focus on elements of the system instead of an integrated system was that it delayed the expected operational date of commercial crew to 2016.

The amount appropriated in FY 2012 was $406M ($444M less than the newly requested amount of $850M). This resulted in a further slippage of the NASA's expected operational date to 2017, assuming funding at the level proposed in the President's FY 2013 request and reasonable technical progress on the part of the commercial providers (many of the potential providers have said that they believe they can service the ISS before 2017).

NASA is planning for commercial crew capability to be in place in 2017; but the Agency's plans will not preclude earlier availability of services. If funding levels are further reduced or if significant technical difficulties are experienced by the commercial providers, then the ability of commercial crew providers to be able to service the ISS by 2020 may be jeopardized.

2. **What critical measures need to be taken to preserve a crewed SLS/Orion flight in 2021 or earlier? What would it take to accelerate the timetable for that crewed flight?**

ANSWER: While adequate funding is critical, the 2017 date of the uncrewed SLS/Orion MPCV test mission is driven primarily by technical development schedules, not funding, and NASA is working to develop these vehicles as rapidly as possible, in part through the use of existing contracts. NASA is currently conducting an integrated technical, schedule, and cost review, which will be completed late this summer. The results of this review will help NASA assess the degree to which it might be possible to accelerate the crewed SLS/Orion MPCV test mission, currently scheduled for 2021, which is primarily driven by budget availability.

3. **You indicate in your statement that you expect Orbital to complete its demonstration flight of their cargo vehicle to the Station by this summer. Orbital has qualified its ability to do so by saying that this would require the upcoming tie-down engine test and *Antares* maiden flight to proceed without any glitches. In light of Orbital's own caveats, please explain the basis for your prediction of "summer".**

ANSWER: Orbital Sciences Corporation (OSC) reported to NASA that, pending the successful completion a hot fire engine test on the pad and the maiden test flight of the Antares, the demonstration flight to the ISS is currently planned to be conducted by the end of September 2012. NASA recognizes that further delays are likely due to challenges in completing the new commercial launch complex at Wallops Island, currently the pacing item, and engineering issues that may be discovered during the upcoming test firing and flight. OSC is required to cover any additional costs due to the delays since NASA makes payments only upon the successful completion of milestones. NASA is closely monitoring OSC's progress and is offering technical assistance to help expedite completion of the Commercial Orbital Transportation Services (COTS) demonstrations flights.

4. I understand that the schedule for contracted-for commercial cargo flights has slipped significantly, with the first CRS flight now scheduled for launch no sooner than later this year.

a. What is the production status of the hardware needed for CRS flights?

ANSWER: Below is the Commercial Resupply Services (CRS) production status for the first two cargo resupply missions for Space Exploration Technologies (SpaceX) and OSC.

SpaceX-1 Production Status
Falcon 9-4 launch vehicle - The interstage and first stage are complete and at the Cape. The second stage has been manufactured and is in Texas for hot fire testing. The Merlin Vacuum engine (MVAC) skirt production is scheduled for completion in June.

Dragon 3 - All Draco thrusters are complete and installed. Berthing Mechanism is installed and checked out.

SpaceX-2 Production Status
Falcon 9-5 launch vehicle – First stage engine section assembly complete. All nine engines installed. MVAC skirt complete.

Dragon 4 - Pressure system capsule built and leak checks completed.

Orbital-1 Production Status
Antares launch vehicle – First stage core delivered to Wallops Flight Facility (WFF). First stage engines at Stennis Space Center awaiting hot fire. Upper stack avionics cylinder, motor cone, payload cone, and interstage have completed testing. The Castor 30B is in final assembly.

Cygnus – Pressurized cargo module is complete. Service module completed thermal vacuum testing.

Orbital-2 Production Status
Antares launch vehicle – First stage core delivered to WFF. Upper stack cylinder and payload cone in manufacturing, with scheduled delivery in July.

Cygnus – The service module propulsion system completed. Service module open panel testing starting. Pressurized cargo module in final assembly.

b. Will each company be able to fulfill the CRS flight rates originally planned for 2013? If not, what flight rates do you expect will be achieved in 2012 and 2013?

ANSWER: Both SpaceX and OSC are making significant progress in preparing for the upcoming demonstration missions to ISS as well as preparing for the first CRS missions. Although the original missions planned for 2013 have slipped somewhat, NASA is confident that the providers will be executing cargo delivery missions to the ISS in the 2012 and 2013 timeframe.

Both SpaceX and Orbital are currently preparing the hardware and mission products necessary to execute the near term CRS flights while they are focused on successfully and safely executing the demonstration flights. Once the COTS demonstration flights are flown successfully, NASA expects that the CRS providers will be able to provide one cargo resupply mission in FY 2012 and up to four in FY 2013.

c. **Will Space X and Orbital be ready to resupply the ISS once they have demonstrated their capabilities in the upcoming demonstration flights?**

ANSWER: NASA expects that each of the CRS providers will be able to settle into a steady production and mission flow once the capability to deliver cargo to the ISS has been demonstrated successfully. NASA is working with both SpaceX and OSC in preparation for the upcoming demonstration flights including demonstrating simulated delivery of cargo to ISS. NASA is currently working with SpaceX to support the first five CRS flights and the Agency is working with OSC to support the first four CRS flights. NASA has identified the cargo manifest for the near term CRS missions and is working with the CRS providers to integrate the cargo into the Dragon and Cygnus vehicles.

d. **What is NASA's contingency plan if any of these CRS flights are further delayed?**

ANSWER: There is sufficient margin in logistics, consumables and systems spares through early 2013 to protect ISS operations for a delay in the start of commercial cargo delivery. On May 22, 2012, SpaceX launched its second COTS demonstration flight, and three days later, the Dragon spacecraft was berthed to the ISS. The mission, which accomplished the remaining COTS demonstration goals for Space X, was brought to a successful conclusion on May 31, with the deorbiting and splashdown of the Dragon capsule. The second mission also demonstrated launch, orbit and successful recovery of a simplified Dragon spacecraft. Commercial Resupply Services (CRS) flights will augment existing resupply capability needed to support the crew on-orbit. Those needs continue to be met through the ESA-provided Automated Transfer Vehicle (ATV), the Roscosmos-provided Progress and Soyuz, and JAXA-provided H-II Transfer Vehicle (HTV) vehicles now that the Space Shuttle has been retired. The U.S. commercial providers are in the process of bringing their vehicles on-line to provide the needed resupply capability. Recognizing the challenges of initial flights and bringing a new vehicle into operations, NASA and its international ISS partners previously delivered additional supplies to accommodate any potential slips to the CRS schedule. The commercial strategy does not rely on a single flight or provider. In addition to SpaceX, OSC has one demonstration flight and one CRS flight scheduled in 2012.

5. **Have the Research Transition Team (RTTs) been successful in ensuring that research and development needed for NextGen implementation is identified, conducted, and effectively transitioned from NASA to FAA?**

ANSWER: Close coordination with its partners in other Government agencies is critically important for NASA Aeronautics. To enable greater and more timely support for the implementation of NextGen, NASA's Aeronautics Research Mission Directorate (ARMD) has formed Research Transition Teams (RTTs) with the FAA and Joint Planning and Development Office (JPDO) to identify the right technologies to develop and conduct well coordinated research including joint field trials to ensure relevancy and accelerate acceptance of new air traffic management tools and technologies. Initially, four RTTs were formed in 2008 for the technology areas where NASA and FAA jointly determined the close collaboration was essential. It is well recognized that the RTT construct has been vital to a success in accelerating transition of NASA developed technologies to FAA enabling FAA's much speedier evaluation and implementation. The four RTTs are described below including several examples of NASA technologies that have been recently transitioned or are about to be.

Under the Efficient Flow Into Congested Airspace (EFICA) RTT, NASA is creating new ways to tackle inefficient operations in congested airspace near terminal areas by improving legacy air traffic control procedures that limit the number of incoming aircraft an airport can handle. During a three-year collaborative effort with the FAA, Boeing, MITRE, Sensis/SAAB, United Airlines, and Continental Airlines, NASA developed and field tested a new capability called Efficient Descent Advisor (EDA) that gives air traffic controllers the ability to better manage incoming traffic in the most fuel efficient manner while ensuring that each aircraft meets its scheduled time for arrival, while avoiding flight path conflicts between aircraft. EDA helps to determine the best time and place to begin a plane's descent so that the plane can make a smooth gliding descent with the engines idling all the way down, saving fuel and making less noise as planes fly over neighborhoods.

The EDA technology was transferred to the FAA on November 30, 2011. The FAA Air Traffic Organization will evaluate the technology and determine the appropriate allocation of EDA functionality to systems and software builds for implementation in the mid-term (2014-2018) NextGen operations. If widely used across the country, the EDA tool has demonstrated the potential to reduce local noise and emissions, reduce flight time and save $300M per year in wasted jet fuel. Test results also showed significant reductions in controller workload, helping to maintain aviation's current outstanding safety record.

Under the Flow-Based Trajectory Management (FBTM) RTT, NASA and FAA researchers conducted work in tools and methods for in-flight "flow-based trajectory management" in NextGen. The FBTM is a set of new software tools and procedures that help air traffic controllers identify and deal with potential traffic issues that might occur in the upcoming 20 to 60 minutes of flight, such as congestion or bad weather. FBTM tools provide practical guidance for modifying flight paths, or trajectories, of one or more aircraft in the face of changing conditions. The concept of FBTM evolved through a series of studies that culminated in 2011 demonstrating an effective method for successful management of future aircraft operations at levels 30 percent greater than today. FBTM can also be integrated effectively into today's operations without additional controller resources. NASA transferred FBTM research results to the FAA in July 2011, where the technology will receive additional testing and evaluation. The FAA will use FBTM results to help develop and deploy traffic management and controller tools to be used in NextGen in the near future. The results support 10 out of 50 Operation Improvements as described in the FAA's NextGen Implementation Plan.

Under the Integrated Arrival/Departure/Surface (IADS) RTT, NASA is collaborating with the FAA to explore how to use NASA's Precision Departure Release Capability (PDRC) to improve the coupling of advanced airspace and surface traffic tools. PDRC allows precision scheduling of departing aircraft to allow for smooth integration into available slots in the high-altitude overhead streams. The FAA plans to incorporate PDRC in Traffic Flow Data Manager (TFDM) Concept Demonstration #2, which begins in October 2012. NASA will continue to work with the FAA TFDM team to support maturation of the PDRC technology for successful transition over the next year.

Under the Dynamic Airspace Concepts (DAC) RTT, NASA and FAA researchers are collaborating on far-term NextGen concepts for demand-capacity management. Under this RTT, NASA researchers have delivered results on the Corridors In The Sky concept to the FAA to help narrow the scope of needed research for far-term concepts on airspace management. This and other concepts for dynamic airspace allocation and structuring are at a lower level of maturity, and hence will require longer collaborative research efforts with the FAA before technology transition is feasible.

6. **You propose to restructure high-speed flight in the Aeronautics Research Mission Directorate. Although you are transferring hypersonics work pertaining to entry, descent and landing to the Space Technology office, you propose to eliminate research into air breathing propulsion systems.**

   - Since NASA's time horizon runs well into the next two or three decades, are we mortgaging our future by ignoring this possible flight regime for civilian flight?

   - What is the Administration's policy with regards to the hypersonics research needs of DOD? Instead of leveraging NASA's expertise and facilities, will DOD need to conduct a separate program? Have you discussed this matter with DOD and what are DOD's plans?

ANSWER: Hypersonic air-breathing technologies require significant further development and testing before they can eventually be utilized for civilian applications such as transportation or space access. The early steps in hypersonics technology development will be military applications. Therefore, NASA Aeronautics is focusing its remaining hypersonic research on efforts that directly support the DoD. Flight experience gained by the DoD will be leveraged by NASA and will be critical for advancing this field for civilian applications. Specifically, NASA is reducing funding for hypersonics research related to air-breathing systems, including propulsion technologies and structurally integrated thermal protection systems. We are, however, maintaining some critical national capabilities related to scramjet propulsion and core competencies to provide support for both Agency and DoD missions. NASA's Space Technology Program will assume responsibility for the fundamental research associated with Entry, Descent, and Landing (EDL). NASA Aeronautics' hypersonic investment will support the NASA Langley Research Center's 8-ft High Temperature Tunnel because it is a key facility for the DoD's hypersonic programs.

NASA is also actively working with the DoD to minimize the impact of these decisions on their missions. NASA has already met with senior DoD officials who agree that the NASA investment does align with the highest hypersonic priorities in the DoD. NASA is aware of the DoD plans to expand research in hypersonic flight systems and is continuing to discuss options to optimize this collaboration. In the same way that NASA supported the development of the USAF X-51 system, we expect DoD collaboration and coordination to continue.

In the meantime, NASA ARMD is focusing its resources on other civil aviation transportation priorities. These include a number of future vehicle types including advanced rotorcraft, civil transports and even supersonic airplanes.

Congresswoman Donna Edwards

March 7, 2012 Hearing
on
An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2013

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1. **When NASA first contracted for cargo resupply services for the International Space Station, initial service flights were anticipated to begin in 2010. At present, the two companies involved are between 20-34 months behind schedule in carrying out the COTS cargo demonstration flights, a necessary precursor to providing actual services.**

   a. **Since the COTS program also was carried out under Space Act Agreements, what do these delays to commercial cargo demonstration flights say about likelihood of the private sector's meeting NASA's 2017 schedule for operational commercial <u>crew</u> flights?**

ANSWER: The schedule delays experienced by our partners over the life of the Commercial Orbital Transportation Services (COTS) program are indicative of the challenges associated with developing and flying new, highly complex launch vehicles and spaceflight systems. The magnitude of the delays is also not outside NASA's experience on previous developmental efforts.

NASA is working with both COTS partners to facilitate their development activities and overcome schedule issues. However, safe and successful spaceflight is the primary objective, not schedule.

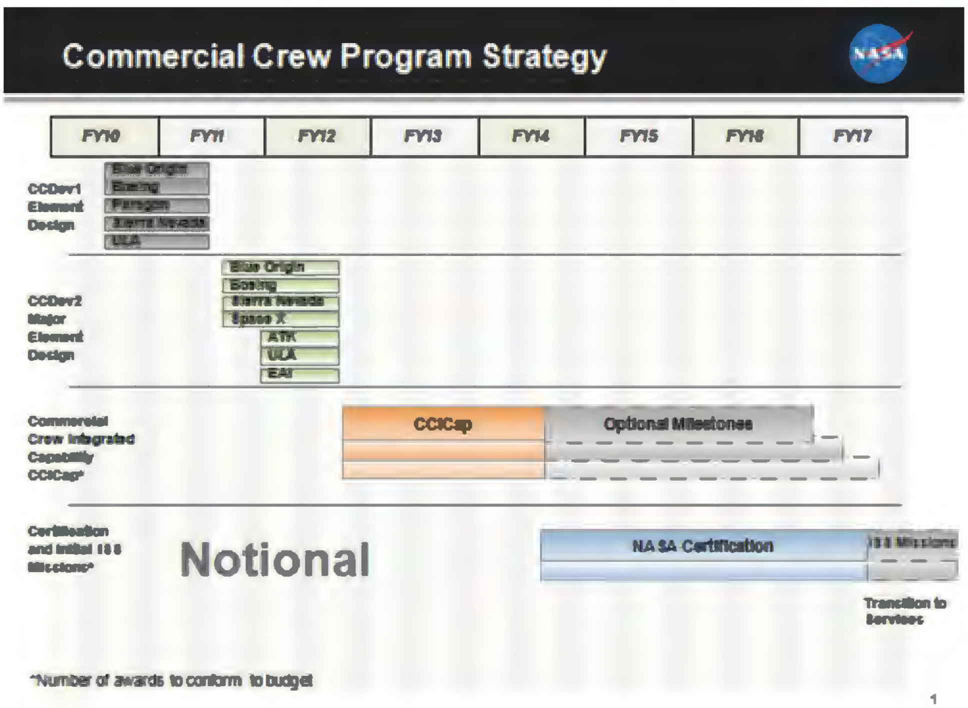
Similarly, the goal of the Commercial Crew Program is also safe and successful spaceflight. Variations from the pre-negotiated milestone dates will be addressed immediately by the Commercial Crew Program Office, along with discussions or documentation to ensure a complete understanding of the reasons for any changes. In some cases, this could result in the planned date of a milestone being changed. With the overall goal of success firmly in mind, the Program Office will work with commercial partners when the results of the partners' efforts to accurately predict the progress of an aggressive and years-long development activity need to be adjusted.

In addition, most of the current commercial providers have indicated that they believe they can be ready prior to 2017. However, NASA's assessment has led to a more conservative estimate of 2017, including predicted budget authority, although earlier delivery of services will not be precluded.

   b. **In establishing 2017 as the new date of when operational commercial crew services will be available, has NASA incorporated all acquisition-related steps that need to be followed by the government in the development and**

procurement of such services? For example, does the timeline account for activities such as solicitation preparation and release; contract competition, award, negotiation, potential protest resolution; and certification for operations involving U.S. astronauts before commencing commercial crew transport services to the International Space Station in 2017? Please provide the steps included in the timeline and estimated time required for the completion of each step.

ANSWER: NASA has incorporated all the necessary acquisition-related steps that need to be followed in order to establish a planned operational date of 2017 for commercial crew services. The steps and timeline are shown in the graphic below, assuming adequate budgets and technical progress on the part of the commercial partners. Details in this strategy are being further refined.



b. **Does the schedule estimate include any contingency margin for unanticipated delays, given the COTS cargo demonstration program participants have experienced delays to date of between 20 and 34 months? If so, how much margin has been included, and if not, why not?**

ANSWER: NASA believes it has included margin for longer than anticipated development schedules. As mentioned above, most of the current commercial providers have indicated that they believe they can be ready prior to 2017. However, NASA's assessment has led to a more conservative estimate of 2017. Given that there are multiple systems in development and each one has its own development schedule, there is not a specific quantitative amount of margin that has been applied to the above schedule. The schedule above reflects NASA's current, best assessment of when commercial crew services missions will be accomplished, assuming adequate budgets and technical progress on the part of the commercial partners.

2. **The Administration appears to insist on a level of rigor in establishing the potential cost of SLS that is not expected for the commercial crew program. Why does the Administration continue to request significantly more funding than authorized for commercial crew without requiring a comparable level of rigor in cost assessment? What would you estimate the confidence level of your cost estimate for the commercial crew program, to be, and on what do you base that confidence level?**

ANSWER: During the FY 2013 budget development process, NASA strove to strike the right balance between all our human spaceflight capabilities. As the primary means of U.S. access to the ISS, NASA wanted to take all steps necessary to provide assured crew access to the ISS and to eliminate our sole reliance on foreign systems.

NASA does not have a "confidence level" associated with the Commercial Crew Program, as the budget was not and cannot be developed with a traditional confidence level. Confidence levels are obtained when using a parametric cost estimating tool that leverages multiple, historical data points for costs for comparable hardware elements. Given that NASA does not have multiple, historical data points to compare (the nearest analogy to a commercial crew system is NASA's Gemini program), traditional cost estimating tools are not appropriate. In addition, NASA is using a unique and innovative acquisition strategy, which we believe, will produce a crew transportation system for significantly lower costs than predicted using traditional models. NASA's understanding of the cost will be improved after seeing the bids from the potential providers, performing analysis on their cost estimates and developing estimates for the cost of certification.

2. **NASA justifies its last minute switch to using Space Act Agreements instead of FAR-based contracts in part on the need to accommodate multiple partners.**

    a. **For the purposes of the commercial crew program, what is your definition of multiple"?**

ANSWER: NASA believes that having multiple companies competing against each other at this stage of the Commercial Crew Program will result in lower overall costs for the Government. In a traditional program with a single prime contractor from the start using a cost-plus contract, the NASA-Air Force Cost Model (NAFCOM) cost estimates are approximately $8-11 billion for the development of an ISS crew transportation capability. Using the current, innovative approach with fixed Government costs, investment from industry, and maintaining competition – NASA estimates being able to cut the development costs substantially and deliver an ISS capability for around $5 billion. Maintaining competition is a key factor in achieving these savings.

NASA plans to have two to three companies involved in the next phase of SAAs, we believe the competitive environment provides strong incentive for the companies to align with NASA's certification requirements in order to remain competitive in the future certification and services phases.

b. **What funding level is needed to accommodate multiple partners through design and development of commercial crew systems that is, having them ready for certification? Please provide the basis for that estimate.**

ANSWER: NASA believes the President's FY 2013 Budget Request is needed to accommodate multiple partners through design and development of commercial crew systems. The Agency has not specified an exact number of partners for the next phase of the program; however, NASA plans to make multiple awards, depending on the quality, number, and overall portfolio benefits of the proposals received.

For the purposes of developing the budget request, NASA estimated a range of potential CCiCap awards from $300-500M per partner. It is assumed this range will support a portfolio of multiple partners. However, the actual proposals and resulting negotiations will determine how many partners may be accommodated. There are multiple ways NASA could fund the awards by using part or all of FY 2013 and FY 2014 appropriations.

4. **Why has NASA now decided not to have an independent cost and schedule estimate performed for the commercial crew program, despite last fall's statements that one would be done?**

ANSWER: The Commercial Crew Program continues to refine its cost estimates for the development effort. Since the Agency decided to implement the next phase of the program under Space Act Agreements (SAAs) instead of contracts, the cost modeling and cost estimates are being reworked. Under a SAA, the partner is paid pre-negotiated fixed amounts upon successful completion of milestones, not based on costs incurred. The CCiCap Announcement for Proposals asks the bidders to estimate their total cost to reach a state of a demonstrated crew flight. As a part of the solicitation effort for CCiCap, NASA will perform independent reviews of bidders' costs and schedules for validity and comprehension to support the CCiCap evaluation.

Once the CCiCap awards are made, during the summer of 2012, NASA will further refine its total cost estimates for development, including the value of performance milestones under CCiCap, and the NASA Certification effort required to complete design and development and finally readiness for services. This effort will be done in the FY 2013 timeframe and at that point, NASA intends to employ an independent cost and schedule estimate. At that time, NASA should have the detailed data necessary for a valid independent cost estimate to be accomplished. The independent review will be incorporated into the Agency's plans prior to any award for a certification contract for commercial crew systems.

Congressman Brad Miller

March 7, 2012 Hearing
on
An Overview of the National Aeronautics and Space Administration Budget for Fiscal Year 2013

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1. **Administrator Bolden, NASA Policy Directive 1050.1!, which deals with the use of Space Act Agreements, states the following:**

   "Funded Agreements may be used only when the Agency's objective cannot be accomplished through the use of a procurement contract, grant, or cooperative agreement."

   NASA has decided to use Space Act Agreements in the next round of Commercial Crew acquisition. This decision was a reversal from an earlier decision to use regular FAR- based contracts for this round of Commercial Crew acquisition.

   Can you explain why the decision was made to switch from a FAR based procurement to a Space Act Agreement-based procurement, and does that rationale comport with NASA's own policy directives on the use of such agreements?

ANSWER: The FY 2012 Consolidated and Further Continuing Appropriations Act provided NASA with $406M for the Commercial Crew Program, which was less than half of the President's Budget Request and may have required NASA to award a single contract for the previously planned Integrated Design Contract (IDC) phase. The Conference Report accompanying the FY 2012 Appropriations Act stated, "NASA is directed to work expeditiously to alter its management and acquisition strategy for the program as necessary to make the best use of available resources and to define the most cost effective path to the achievement of a commercial crew capability."

Upon performing a reassessment as directed, NASA determined that the most cost effective path to the achievement of a commercial crew capability in light of the $406M appropriation in FY 2012, and the uncertainty associated with the FY 2013 budget levels, was to alter the Commercial Crew Program acquisition strategy. Rather than moving forward with awarding a single firm-fixed price contract for IDC, which would remove future competition for follow-on Certification phase of the program, NASA will continue to support the design and development of commercial crew transportation through the use of multiple funded Space Act Agreements (SAAs). NASA will shift the formal design acceptance and certification planning acceptance to the follow-on Certification Phase. Utilizing SAAs for the next phase provides tangible benefits in terms of cost and schedule flexibility in comparison to FAR-based contracts. SAAs are also expected to provide more flexibility to deal with possible variations in funding levels without the need for potentially protracted and inefficient contract renegotiations. NASA believes this change is consistent with all applicable laws and policy directives.

SUBCOMMITEE ON INVESTIGATIONS AND OVERSIGHT
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Questions for the Record

"NASA Cyber Security: An Examination of the Agency' Information Security"

Questions for Ms. Linda Cureton,
Chief Information Officer, National Aeronautics and Space Administration

Questions submitted by The Honorable Dr. Paul Broun, Chairman

1. What are the greatest threats facing NASA IT Security?

Answer: The greatest threats facing NASA IT Security (in no particular order) are:

- IT Governance complexities (fragmented enterprise; no direct authority);
- Difficulty in maintaining a secure posture in a diverse physical environment (multiple operating systems, platforms, mobile devices, etc.);
- Lack of enterprise visibility into assets, system configuration, network traffic and patch status in a fragmented environment;
- Well-resourced, motivated and skilled adversaries and attackers that view NASA as an enticing target;
- Poor execution of security practices by individuals, organizational entities, contractors, and service providers.

a. What is NASA doing to address those threats?

Answer: Threats and cyber attacks are a constant factor to consider as NASA manages its enterprise infrastructure. NASA is taking prudent steps to improve the security posture of the Agency networks and applications:

- NASA is focusing enterprise IT Security assets on the greatest threats – hackers, nation-states, foreign intelligence services, malware, and web applications.
- NASA is working with the owners of IT Systems to ensure asset data, system configuration/patch data, and network traffic is available for correlation and examination to continuously assess the security posture of the enterprise.
- NASA is tracking the campaigns of attackers based on collective attack methods. Analysis and intelligence will provide data to mitigate the spread of future incidents and implement a prevention method.
- NASA is working with external sources, both public and private, on the sharing of threat and intelligence information focused on its mission space.
- While the NASA Office of the CIO (OCIO) doesn't directly control or manage mission systems, the OCIO is actively engaging the Mission Directorates through the governance process to participate in IT Management Board and IT Security Advisory Board activities. In addition, the OCIO is working to gain access to Mission Directorate systems to perform vulnerability scans, asset discovery, and patch management activities.

- NASA is exploring innovative solutions that can provide collaborative web services to NASA scientists and engineers.

2. IT Security funding is often bundled with mission funding, which you have limited visibility into. Can you provide a better estimate of what NASA spends protecting its systems overall?

Answer: 5.7 percent ($82.2M) of the Agency's $1.4B IT Budget (NASA FY 2013 President's budget submission) is allotted for IT Security. The CIO directly controls $15M of that $82.2M.

NASA IT and IT Security Funding ($M)*				
	FY10	FY11	FY12 Estimate	FY13 President's Budget
Agency Budget	**18,724.3**	**18,448.0**	**17,770.0**	**17,711.4**
Agency IT Budget	**2,070.0**	**1,686.9**	**1,442.1**	**1,440.2**
IT Security Budget	**72.5**	**88.7**	**86.2**	**82.2**
IT Security Budget as a % of the Agency IT Budget	**3.5%**	**5.2%**	**5.9%**	**5.7%**

*Comparative estimate of OMB Congressional and Annual OMB Exhibit 53 submissions

3. Given your limited insight into the Mission Directorates, how do you currently work with them to ensure that adequate security measures are undertaken to safeguard their networks and protect mission operations?

Answer: The OCIO has requested participation from the Mission Directorates in NASA's IT Security Advisory Board, where Agency information security professionals collaborate on solving the IT Security issues across the enterprise. Each Mission Directorate manages risk within their operational boundary. To improve the collective effort to mitigate risk across the enterprise, the OCIO is working with the Mission Directorates; to ensure that NASA's enterprise IT Security tools are deployed to monitor Internet-connected devices.

The OCIO publishes well defined polices, standards, and procedures requiring all IT assets meet specific security principles. The OCIO also publishes several baselines and standards for hardware (i.e., Federal Desktop Computer Checklist (FDCC - replaced by the United States Government Computing Baseline - USGCB), Center for Internet Security (CIS) benchmarks, and other computer and server Operating System baselines) and software (i.e., Internet Explorer, Adobe, Microsoft Office, etc.) configurations for Centers and Missions to follow. NASA also requires testing of security controls in accordance with the systems risk profile.

The OCIO is monitoring the networks the OCIO has access to for known hostile activity. NASA is sharing and receiving threat information related to NASA's domain that is improving the Agency's ability to manage the vulnerabilities on the Agency's networks.

4. What information does the Systems Operations Center (SOC) have access to?

Answer: The SOC has access to Agency enterprise institutional/administrative network traffic via Intrusion Detection Systems and packet capture devices that include:

- Network logs, such as firewalls and Domain Naming Servers;
- System asset data, patch status, vulnerability status, and limited anti-virus data; and
- US-CERT threat reports.

a. Is it simply enterprise systems, or do they have access to Mission Directorates systems?

Answer:

- The SOC's information is collected from the Agency's institutional/administrative systems.
- In addition, the SOC collects and analyzes IT Security incidents when these incidents are reported by mission IT security personnel through the SOC's Incident Management System.
- The SOC has limited access to mission networks through a limited number of Intrusion Detection Systems placed on those networks.

5. Now that the Security Operations Center has been operational for a few years, what lessons have you learned and what are your future plans to enhance or modify the capabilities at the SOC.

Answer: A few of the lessons learned by the NASA SOC after being operational for a few years are:

- The SOC needs to improve its operational visibility and situational awareness relative to network monitoring, system assets, system vulnerabilities, system patch and configuration status, and enterprise coverage.
- Log data acquired and analyzed in near real-time is a critical element toward reducing the damage caused by adversaries. Reviewing log information enables the SOC to provide Centers and Programs with recommended actions to mitigate and possibly prevent repeats of events.

The future plans for the SOC include improved efficiency through a proactive engagement strategy to better prevent, protect against, and predict attacks by:

- Developing a working partnership with Agency IT service providers to proactively block or re-direct hostile attacks.
- Improving the collection and analysis of data from external sources.
- Improving threat data delivery to Agency stakeholders.
- Expanding network monitoring to include the Mission Network.
- Instituting a means to research, develop and deploy a distributed intelligence framework.
- Enhancing SOC capabilities by continuously evolving services to improve defense of the IT infrastructure.

6. What is the greater threat to NASA information security – outside network penetrations, or internal leaks and spillage?

Answer: The greater threat to NASA is from external penetrations.

a. Does your current budget similarly prioritize these threats?

Answer: The current budget sets network boundary protection and network monitoring as a priority.

7. Based on the observed intrusions, can you identify the motivations for attacking NASA systems –theft, espionage, sabotage, and vandalism?

a. How do these intrusion types rank?

Answer: From the perspective of the impact to the Agency, NASA would rank the intrusions in the following order:

1) Espionage
2) Theft
3) Vandalism
4) Sabotage

- *Espionage is considered to be NASA information that is obtained via overt, covert, or clandestine activity with intent, or reason to believe, that the information will be used to the injury the United States, or to the advantage of a foreign nation.*
- *Theft is considered to be an unlawful taking (as by embezzlement or burglary) of NASA property or information.*
- *Vandalism is considered to be a willful or malicious destruction or defacement of property, including NASA websites.*
- *Sabotage is considered an act with intent to injure, interfere with, or obstruct the mission of NASA by willfully injuring or destroying, or attempting to injure or destroy, any NASA mission or materiel, premises, utilities, including human, or information resources.*

8. How effective are you in assessing compliance with security configuration baselines within Mission Directorates? Do the FISMA reporting requirements help you better understand the security posture at the Mission Directorates?

Answer: The OCIO has limited authority to impose cyber security solutions across Mission Directorates. This includes limited visibility into security configuration baselines across a wide array of operating systems, many of which may be obsolete and/or specifically configured for Mission requirements.

Most Mission Directorate sensitive information is stored in 'air gapped' network environments. In most cases, the OCIO does not have access to these network environments in order to assess compliance.

The OCIO uses a set of automated tools to prepare the data for the Federal Information Security Management Act (FISMA) report. The use of these tools assists the OCIO in understanding the security posture of the Mission Directorates.

9. With government-wide efforts to move information to the "Cloud," how will NASA ensure that information is appropriately secured - particularly when it is experiencing so many challenges already?

Answer: To ensure the security posture of Cloud service providers is properly understood, a new NASA Agency team has been tasked with developing the process that will be used to authorize NASA clouds providers by leveraging the work done through the Federal Risk and Authorization Management Program (FedRAMP), a government-wide program that provides a standardized approach to security assessment, authorization, and continuous monitoring for cloud products and services. (Members of the NASA team were also members of the Cloud Computing Security Working Group that advised GSA on Security Control Parsing for the FedRAMP approach.) The team will create a process to understand exactly which security controls are being addressed by a Cloud provider and which security controls will remain the responsibility of NASA. The team will subsequently execute the process developed to authorize new Cloud providers for use by NASA. The process findings will also be used to ensure each new Cloud provider's services interface and integrate as needed with existing NASA security processes and mechanisms. Additionally, the findings will be used to create Cloud provider-specific security guidance for NASA employees.

10. How long would you estimate it would take the Office of the CIO to close out all of the 18 open NASA IG recommendations?

Answer: The estimate based upon current resources to close out all of the 18 open NASA IG recommendations is June 2013.

11. Shortly after the hearing, press reports indicated that Administrator Bolden circulated a memo outlining steps to address IT security weaknesses. Please provide a copy of that memo to the committee.

Answer: A copy of the memo is attached

12. After the hearing, Administrator Bolden appeared before another Committee and addressed many of the issues brought to light at our hearing. Specifically, Administrator Bolden indicated that the theft of a laptop containing algorithms used to command and control the International Space Station never put the orbiting laboratory at risk because "[t]hey would still have to get through another set of firewalls at the Johnson Space Center because everything that goes to the International Space Station, as it did with the shuttle, is encrypted prior to transmission..." During our hearing, the NASA IG stated:

> *"In FY 2011, NASA reported it was the victim of 47 advanced persistent threats (APT) attacks, 13 of which successfully compromised Agency computers. In one of the successful attacks, intruders stole user credentials for more than 150 NASA employees - credentials that could have been used to gain unauthorized access to NASA systems. Our ongoing investigation of another such attack at the Jet Propulsion Laboratory (JPL) involving Chinese-based Internet protocol (IP) addresses has confirmed that the intruders gained full access to key JPL systems and sensitive user accounts. With full system access the intruders could: (1) modify, copy, or delete sensitive files; (2) add, modify, or delete user accounts for mission-critical JPL systems; (3) upload hacking tools to steal user credentials and compromise other NASA systems; and (4) modify system logs to conceal their actions. In other words, the attackers had full functional control over these networks."*

The IG also stated, "Moreover, even after NASA fixes the vulnerability that permitted the [ATP] attack to succeed, the attacker may covertly maintain a foothold inside NASA's system for future exploits."

I hope that NASA did not dismiss the risk simply because ISS control algorithms are encrypted and transmitted by a NASA center. I understand that JPL is not a NASA center (and presents unique IT security challenges itself), but the JPL intrusion demonstrates that NASA facilities are not immune to attack. Similarly, the U.S. China Economic and Security Review Commission recently noted in its annual report to Congress, the Terra and Landsat-7 satellites "have each experienced at least two separate instances of interference apparently consistent with cyber activities against their command and control systems." Although the Commission did not attribute this interference to any specific actor, it does demonstrate that encrypted transmissions do not guarantee the safety of command and control systems.

While it is reassuring that NASA believes that the ISS was never at risk, I am interested in understanding what lead NASA to this conclusion.

a. Please provide any and all analysis that demonstrates that the March 2011 theft of an unencrypted NASA notebook computer, which resulted in the loss of the algorithms used to command and control the International Space Station, was never a risk to mission operations or safety.

Answer: The Johnson Space Center (JSC) Mission Operations Directorate (MOD) performed a review of the file contents of the stolen laptop and determined there were two items of interest:

1. Copies of displays used on the Space Station's Portable Computer System (PCS). The displays are more than just a screenshot, but in an Extensible Markup Language (XML) format that is both human readable and machine readable, independent of computer platform (windows PC, Macintosh, or UNIX). For comparison purposes, the latest versions of Microsoft Word use a version of XML. These displays were on the laptop as needed for task assignments. These displays on a standard laptop are non-functional displays and cannot receive telemetry from the ISS and/or send commands to the ISS.
2. Although not actual software, the Software Requirements Specifications for the Command and Control Software was another document found on the stolen laptop. This document contains specification on the software and is used to understand how the software works and interfaces with other software on the ISS.

Next, the MOD evaluated the risk to the International Space Station due to the loss and concluded the following:

- The stolen laptop was a general purpose, office laptop used primarily for reading email, reviewing documents, and managing task assignments. The laptop was not a specialized laptop to support mission operations.
- Although the laptop had software specifications, it did not contain actual software code that could be used to command and control the ISS.
- By design, mission systems do not permit commanding to a spacecraft from any office-IT device (laptop, desktop, personal digital assistant (PDA), etc.) that is not physically located inside the mission systems firewall at Johnson Space Center (JSC) or a small number of other NASA locations that connect directly to the JSC mission Local Area Network (LAN).
- Even with the correct network connection, several layers of credentials in several different network security systems are required.
- Under no circumstance is a remotely connected office-IT device permitted command access.

b. Was this determination made by the CIO or the Human Exploration and Operations Mission Directorate?

Answer: The determination that the International Space Station was not at risk was made by JSC's Mission Operations Directorate with concurrence from the Human Exploration and Operations Mission Directorate (HEOMD) and not by the NASA CIO.

Once the Incident Response Team identified what specific data was lost and identified the data as belonging to the Mission Operations Directorate (MOD) completed an assessment regarding the risk to the International Space Station resulting from the exposure of this information. It was determined that the technical information contained on the laptop posed no risk of sabotage, terrorism, hacking or malicious interference by any entity to any person, vehicle, agency or company.

a. Was the Science Mission Directorate (SMD) consulted prior to this determination?

Answer: Due to the distinct difference between the operational and scientific missions of the Human Exploration and Operations Mission Directorate (HEOMD) and Science Mission Directorate (SMD), in addition to the type of data lost – data related to operational requirements and planning, SMD was not consulted in determining the risk to the International Space Station.

b. Were the Terra and Landsat -7 satellites ever at risk?

Answer: There were attempts made to establish command of the Terra spacecraft through radio frequency communications. None was successful. This was not a cyber-attack but a command-link intrusion attempt over radio frequency communications. US Space Command and associated organizations were consulted, and found no evidence of NASA IT infrastructure being used in the command-link intrusion attempts.

NASA provides support to the United States Geological Survey (USGS) for the Landsat-7 spacecraft; USGS is responsible for the Landsat-7 spacecraft and associated risk.

13. At the hearing, you indicated that the Mission Directorates are responsible for IT security of their operations. Who is responsible for ensuring that the Mission Directorates comply with Agency IT security directives? Does your office have the appropriate expertise to evaluate threats to the Mission Directorate operations?

Answer: The CIO is responsible for ensuring compliance with NASA and Federal IT security program requirements across the enterprise and in advising senior NASA officials of their associated responsibilities. The OCIO provides governance, and compliance oversight of the Mission Directorates; provides security services for Center and Mission use; and, provides security practices, standards, and guidelines for the Agency. The Mission Directorates are responsible for the application of OCIO policies, procedures, processes, and guidelines as they apply to government-wide regulations and NASA policy. In order to ensure an enterprise wide approach to evaluating threats and risks, OCIO is completing a comprehensive Risk Management Framework (RMF) which will include mission activities.

14. On March 5, 2012, a NASA laptop computer containing sensitive Personally Identifiable Information (PII) was stolen from a NASA KSC employee.

NPR 1382.1 states that "[a]ny PII on mobile computers/devices shall, at a minimum, be encrypted by users with Entrust or native encryption in Microsoft and Apple operating systems or any other NASA CIO-approved encryption solution. It also states that "[w]hen any mobile storage device contains PII, users shall label the device, at a minimum, with 'NASA Privacy Information; Protect Accordingly.'" Further, NPR 1382.1 states that "Employees shall only remove PII from NASA premises or download and store PII remotely under conditions prescribed in NPR 1600.1"

NPR 1600.1 states that "Laptop computers and other media containing SBU information will be stored and protected to prevent loss, theft, unauthorized access and unauthorized disclosure. Storage and control will be in accordance with NPR 2810.1."

NPR 2810.1 states that the Center CISO shall "[e]nsure that portable and removable digital media devises are guarded using encryption solutions which are compliant with federal encryption algorithm standards and NIST guidance, and are in accordance with NASA requirements regarding the protection of sensitive information. NPR 2810.1 also states that "[t]he NASA user shall mitigate the risks of data loss by securing and protecting media under their control, and the information contained on/within those devices, through the use of encryption, access restrictions, and/or sanitation."

a. Was the laptop in question encrypted?

Answer: No, the laptop in question was not encrypted.

b. Did that encryption satisfy the requirements in NPR 2810.1 and NPR 1382.1?

Answer: No, the laptop in question was not encrypted, and therefore did not satisfy the requirements in NPR 2810.1 and NPR 1382.1.

c. Was the laptop in question appropriately labeled as outlined in NPR 1382.1?

Answer: No, the laptop in question was not labeled as required in NPR 1382.1.

d. Was the laptop in question removed from NASA premises under conditions prescribed by NPR 1382.1, NPR 1600.1, NPR 2810.1?

Answer: No. Although the employee has an active Entrust PKI account, which gives the ability to encrypt, Entrust was not used to protect the PII information stored on the stolen laptop.

The OCIO has a plan to implement a Data-At-Rest (DAR) solution to protect the entire hard drive of a laptop.

Additionally, the stolen laptop was not appropriately stored and protected – as the employee left the laptop in an unlocked, car parked in the driveway of her house.

e. Are you, the Center Chief of Security, or the Assistant Administrator of the Office of Protective Services responsible for ensuring the implementation of media protection security protocols?

Answer: OCIO and Center CIO's work together to establish the policy and implementation of media protection security protocols related to Information Technology systems.

f. Who is responsible for ensuring the protection of Agency PII?

Answer: The NASA CIO is tasked with the overall responsibility of protecting Agency PII and other sensitive information in collaboration with all of NASA's employees, contractors and volunteers.

Message from the Administrator

The Importance of Securing NASA Laptops, iPads, and Smart Phones

By now, many of you have either read or heard about the most recent IG report on alleged deficiencies in how we handle and control IT portable devices issued to our NASA employees. I take the issue of IT security very seriously – both for our equipment and the information stored on it. Information security maintains the integrity of our programs, and ultimately keeps our missions and people safe.

The nature of NASA work makes laptops and other portable IT devices important to our program delivery. Many employees use these devices outside the standard office environment during travel and when routine work occurs outside of an office. Therefore, the risk level is increased, and our need to protect the equipment, and the information stored on that equipment is even more elevated than ever before.

We have made significant progress to better protect the agency's IT systems and are in the process of implementing the recommendations made by the NASA Inspector General in this area.

While the cost to replace lost or stolen IT devices is a concern, the real damage is done through the loss of NASA program information, including personal and other sensitive information. Losses such as these have the potential to harm NASA's credibility, can diminish the public trust, and have adverse effects on our ability to deliver and manage agency programs.

Information security is not the sole responsibility of a few individuals or offices at NASA; it is critical that every member of the NASA team take appropriate steps to keep sensitive information safe and protect equipment from theft.

I'm asking every NASA employee today to review the IT policies set forth by the Chief Information Officer, identify areas that require improvement in accordance with those policies, and work with your supervisor and IT team to remedy the situation so that the equipment and information you are using meets the prescribed requirements for security. As a best practice for protecting and safeguarding laptops and other portable IT devices and sensitive data they may contain, I ask that you review and follow the below policies and directives:

- NPD 4200.1B, Equipment Management
  http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPD&c=4200&s=1B
- NPR 2810.1A, Security of Information Technology
  http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=2810&s=1A
- NID 1600.55, Sensitive But Unclassified Information (SBU)
  http://nodis3.gsfc.nasa.gov/OPD_Docs/NID_1600_55_.pdf

- NPR 1382.1, NASA Privacy Procedural Requirements
  http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_1382_0001_&page_name=Chapter1

Policies are just a guideline for action. It is essential that each of us not only familiarizes ourselves with the relevant IT security policies, but also adopts them into our daily practice – to make them an integral part of our habitual behavior and personal discipline.

As a reminder, any equipment losses must be reported to the NASA Security Operations Center Hotline at 1-877-627-2732 or via email at soc@nasa.gov within 1 hour of occurrence.

If you have any questions or concerns, please contact Valarie Burks, deputy chief information officer for IT security, at valarie.j.burks@nasa.gov or 202-358-3716.

The NASA CIO's office has set up a mailbox at Agency-IT-Security@mail.nasa.gov where you can send specific questions, suggestions or recommendations about how NASA can continue to improve its information security.

Thank you for all the work you do every day to help us achieve NASA's mission.

Charlie B.

The Honorable Frank R. Wolf
Chairman, Subcommittee on Commerce, Justice, Science, and Related Agencies
Questions for the Record
Hearing on FY 2013 NASA Budget Request

Planetary Science

1. NASA is defining a new, smaller Mars mission to replace the 2016 and 2018 missions previously under development. Please provide a detailed schedule for when the preliminary and detailed mission concepts will be completed and submitted to the Congress for review.

   Answer: The NASA Administrator has directed the Associate Administrator for the Science Mission Directorate (SMD) to lead Mars program reformulation activities working with the Associate Administrator for Human Exploration and Operations Directorate, the NASA Chief Technologist, and the NASA Chief Scientist. In support of this reformulation, NASA has established a Mars Program Planning Group (MPPG), to develop options for a program-level architecture for robotic exploration of Mars that is consistent with the President's challenge of sending humans to Mars in the decade of the 2030s, responsive to the primary scientific goals of the 2011 NRC Decadal Survey for Planetary Science, and consistent with the President's FY 2013 budget request. The MPPG is expected to identify potential investigations and options in sufficient detail for NASA to be able to select and initiate high pay-off mission(s) for launch as early the 2018 opportunity, and to facilitate NASA's decision-making process for a reformulated Mars Exploration Program. In concert with the Mars Exploration Program the MPPG will communicate with customers, stakeholders and partners to ensure a collaborative and responsive set of investigations and options, This process will inform NASA's development of its FY 2014 budget submission.

   The MPPG will provide NASA with progress reports in April, June, and August. These reports will provide senior NASA leadership (cited above) decision-making opportunities to steer the MPPG in investigation and architecture options, and the Mars Exploration Program in associated budget development. NASA will use this information to formulate its FY 2014 budget request. We anticipate that NASA will be able to brief the relevant Congressional Committees on progress periodically through the summer, and will be able to provide more detailed briefings on proposed mission architecture after the release of the President's FY 2014 budget request in early 2013.

2. The Science Mission Directorate funds and manages its programs based on scientific priorities. The Administration has indicated, however, that the new Mars mission will pursue a mix of science and human exploration goals. Once you introduce non-science content into the science program, are you compromising the integrity of the scientific prioritization process? How do you balance the value of this quasi-exploration program against other purely science-based missions within the Directorate?

   Answer: The National Research Council's (NRC) Decadal Survey for Planetary Science notes that NASA's science program and the human exploration program can both benefit from carefully crafted intra-agency partnerships and it cites NASA's Lunar Reconnaissance Orbiter (LRO) as a good recent example. We envision using the LRO experience to help guide development of our future Mars plans. Additionally, the Mars Science Laboratory's "Curiosity" rover also carries a contribution from the Human Exploration and Operations

Directorate—the Radiation Assessment Detector (RAD) instrument—that provides critical measurements directly applicable to human safety on the Martian surface.

In addition, the Planetary Decadal Survey also noted that technology development is fundamental to a vigorous and sustainable program of planetary exploration. A recent example of how this can work effectively is the provision by the Human Exploration and Operations Directorate of an optical communications technology experiment package to fly on the SMD's Lunar Atmosphere and Dust Environment Explorer (LADEE) planned for launch in late calendar year 2013.

3. The budget request includes a new $10M line in Planetary Science entitled "Joint Robotics Program for Exploration". The purpose of this money is to develop instruments relevant to human exploration and to analyze data from those instruments for strategic knowledge in support of human spaceflight. Why is Planetary Science the appropriate place to fund such an initiative? How much substantive work on instrument development can really be accomplished with $10M?

   Answer: NASA's Joint Robotics Precursor Activities (JPRA) are jointly funded by the SMD ($10M annually) and the Human Exploration and Operations Missions Directorate ($20M annually). By developing an integrated set of priorities, JRPA will leverage mission opportunities, data, and the talents of both the exploration and science communities to help prepare for future human missions to Near-Earth Asteroids (NEAs), the Moon, and ultimately Mars. SMD's Planetary Science Division is the repository of NASA's 50-plus years of lunar and planetary exploration experience and it is the obvious location for SMD's portion of this joint program.

   In general, with $30M in total annual funding, Joint Robotic Precursor Activities will include:
   - Development of instruments for NASA and non-NASA missions to destinations relevant to human exploration beyond LEO to gather needed information;
   - Research and Analysis efforts to generate strategic knowledge in support of human spaceflight planning and systems development;
   - Conduct of strategic studies and hold joint workshops to further inform and leverage community participation; and,
   - Laying the groundwork for future precursor missions.

Human Exploration

4. The budget requests for MPCV and SLS represent a decrease relative both to last year's enacted funding and to NASA's Independent Cost Assessment numbers for fiscal year 2013. Why do you feel that a decrease for these activities is appropriate?

   Answer: For FY 2012, the Congress appropriated $1.943B for SLS and associated ground systems, $15M above the ICA profile when adjusted to include civil service labor. Also for FY 2012, the Congress appropriated $1.200B for Orion MPCV, $181M above the ICA profile when adjusted to include civil service labor.

   The current NASA budget – which was built on the NASA Authorization Act of 2010 – prioritizes urgent needs for a sustainable long-term program. This includes extending ISS operations and utilization to at least 2020, supporting the development of commercial systems for cargo and crew transportation to and from low-Earth orbit (LEO), and developing the next generation Orion Multi-Purpose Crew Vehicle (Orion MPCV) and Space Launch System (SLS), which will take U.S. astronauts beyond LEO on missions of deep space exploration. NASA is assuming out-year budget levels commensurate with an evolvable, capability-driven, multi-destination exploration architecture that will support NASA in achieving a target of reaching a specified destination. The FY 2012 Appropriation starts NASA on the path to enable near-term objectives to be met, including the Exploration Flight Test (EFT-1) test flight in 2014. This flight will inform the ongoing flight and ground systems design efforts leading to the first un-crewed test flight of the SLS and Orion MPCV in 2017. The funding level for SLS, Orion MPCV, and Exploration Ground Systems (EGS) efforts requested in the President's FY 2013 budget supports such an initial test flight of the system by the end of 2017, with an initial crewed test flight in 2021.

It is important that these efforts move forward in an integrated fashion, in terms of both cost and schedule planning.

5. At the level of spending proposed in the budget request, would NASA still remain on schedule for an MPCV flight test in 2014, an MPCV ascent abort test in 2016 and an integrated MPCV-SLS test flight in 2017?

   Answer: Yes. NASA is on track to achieve the Orion MPCV flight test in 2014 and integrated SLS-Orion MPCV test flight in 2017. Other program milestones are in review as part of the FY 2014 budget formulation process.

6. Could additional funding speed up your progress, or are there logistical factors, such as manufacturing capacity, that constrain your ability to meet these test flight milestones any earlier than currently planned?

   Answer: Each of these flights is constrained by manufacturing capacity; additional funding would not accelerate these planned milestones, though it could provide increased schedule confidence.

7. While the MPCV and SLS development budgets are decreasing under the President's budget proposal, costs for exploration-related ground systems are increasing. Why is this? Are ground systems behind schedule relative to the development of the launch vehicle and crew capsule?

   Answer: The Exploration Ground Systems effort is a key element supporting the Orion MPCV and SLS programs. Ground systems costs are down significantly from what was planned in the Constellation program by more than half. The requirements for ground systems development in support of exploration have been reviewed and now provide the minimum, single-string capability to support the planned flight test in 2017. While the SLS and Orion MPCV efforts are not at the point where they are ready to enter full development, some of the elements to be developed under the Exploration Ground Systems effort have long lead times. This will ensure that critical systems will be available to support SLS and Orion MPCV when they are ready to commence flight-testing.

8. NASA expects to have a baseline lifecycle cost estimate for SLS and Orion around this time next year. At that point, will NASA finally be ready to share outyear budget projections for these programs that are more than notional?

   Answer: While NASA's outyear budget projections will have increasing fidelity in the next year, SLS and the Orion MPCV are not slated to go through post-Preliminary Design Review (PDR) and KDP-C until FY 2013; it is at this point that NASA will be able to provide a lifecycle cost estimate for those vehicles.

9. GAO's "Quick Look" assessment of NASA programs reported that NASA is saving money in the Orion program by delaying the acquisition of components needed to enable Orion to support the Space Station. Acquiring these components if and when they become necessary would take approximately 2 years. Does this strategy present a risk that Orion will be unable to serve in its statutory role as backup access to the Station in a timely manner?

   Answer: The 2017 date of the uncrewed test flight of SLS/Orion MPCV is driven by engineering challenges, and would not be accelerated to a great extent with increased funding. NASA anticipates that commercial crew transportation services to ISS will be available in 2017. If this is not the case, and if Russian Soyuz services are also unavailable, NASA could potentially move the 2021 date of the crewed test flight forward with increased funding, fulfilling the back-up role of SLS/Orion MPCV, however as previously noted, this would be a highly inefficient use of the MPCV.

10. The "Quick Look" assessment also found that the lack of a defined mission goal is requiring NASA to build many flexibilities into the SLS design so that it will be able to accommodate any mission that is eventually selected. Does this imply that setting a specific mission goal for SLS would allow you to drop unnecessary flexibilities, reduce risk and therefore reduce costs?

    Answer: NASA does not agree that we are building too many flexibilities into the SLS design. The core capabilities being designed into the SLS are those fundamental capabilities that are needed for multiple potential missions based upon an evolvable design. Basing the design on a single near-term destination could make it very difficult to later modify the design to reach other destinations such as Mars.

Commercial Crew

11. NASA hasn't defined its strategy for transitioning from CCiCap to a traditional contract for the certification and service phases of the commercial crew program. This transition could provide difficult, especially if competitors have to engage in redesigns to meet contract requirements. What risk does this undefined transition plan pose to the program's budget and schedule?

    Answer: NASA is making the definition of the transition plan between CCiCAP and the subsequent certification phase a high priority. A team has been established and NASA should start to see the initial results of their efforts in the months ahead. This activity will allow the Agency to mitigate much of the risk associated with the transition to the certification phase, which is not scheduled to occur for more than two years. In addition, NASA has released the baseline set of safety, performance, and mission success requirements for ISS crew transportation to all of industry. Although compliance with these requirements is optional for industry under a funded SAA, NASA anticipates that providers will use the NASA requirements to inform their development activities thereby reducing the technical risk of future redesign.

12. Will we be relieved of the cost of purchasing Soyuz seats as soon as the first commercial crew capability enters in to service, or do you expect to pay for some overlap of services? If you believe some overlap might be desirable, how long would we be paying for both Russian and commercial services simultaneously?

    Answer: NASA currently plans to discontinue purchasing Soyuz transportation services once the first commercial crew capability enters service.

13. Some people are concerned that the Russians will raise their per-seat prices at exorbitant rates due to the absence of viable current alternatives. What kind of leverage does NASA have in negotiations for additional seats to keep prices in check?

    Answer: The current Russian services contract extends into 2016, and NASA anticipates that U.S. commercial crew providers will be able to provide services in 2017. It is important to note that the International Partners are dependent on NASA for the operations and maintenance of the ISS; the interdependence of the Partners helps keep costs for services reasonable. It is also important to remember that the International Partners have been reliant on the Russians for crew transportation for most of the program and for crew rescue for the life of the ISS Program.

China

14. What is your assessment of the likelihood that the Chinese government will achieve the goals (especially relating to human spaceflight) laid out in its most recent 5-year plan for space activities?

    Answer: Consistent with restrictions codified in Section 539 of the FY 2012 Consolidated and Further Continuing Appropriations Act (P.L. 112-55), NASA has no ongoing or planned bilateral activities with China or Chinese-owned companies and as such it difficult to comment on the likelihood of China achieving the goals laid out in its most recent 5-year plan. Additionally, although I have reviewed the plan, China does not publicly release information regarding its space budget or its policymaking process. Nonetheless, based wholly on China's record over the past few years of achieving its publicly stated space-related objectives, the most recent five-year plan for space activities appears to be a credible guide to the nation's space priorities and ambitions. Accordingly, it is reasonable to expect that China may achieve many of the objectives (especially those relating to human spaceflight) laid out in its current plan.

15. If the Chinese were to successfully achieve the goals of that plan, how would the quality and quantity of their achievements compare to what NASA expects to do over that same time period? What will be our relative positions in terms of space leadership at the end of those 5-years?

    Answer: As noted above, it is difficult to compare China's proposed space program objectives with NASA's likely accomplishments over the next 5 years. The current development path of China's emerging space program appears to mirror the progress made by the U.S. in the 1960s and 1970s. Advances will potentially be marked by historic technological milestones such as demonstrating short-term habitation of an orbiting space laboratory, completing a regional GNSS constellation and perhaps even landing a robotic rover on the moon, but China's level of technological sophistication remains behind that of the U.S. today. In contrast, as a mature space program, NASA's likely achievements in the next 5 years will reflect more consistent innovation and progress across a broader range of space exploration and science activities that currently include dozens of complex active and planned human and robotic missions throughout the solar system.

The NASA FY 2013 budget request and associated out-year budgets will allow the Agency's human spaceflight, exploration, science, and aeronautics programs to maintain their pre-eminent status at the top of global science, engineering, and technology. The International Space Station will continue its strong role in showcasing the advantages of long-term international human presence in space for microgravity-based research. NASA's efforts to foster commercial crew and cargo capabilities to low-Earth orbit (LEO) will allow U.S. industry to conduct many of the same activities being undertaken by the Government of China for the very first time. In parallel, NASA will continue to focus its efforts on the development of the next generation of heavy-lift launch vehicle and a multipurpose crew vehicle for use beyond LEO. NASA's planned upcoming science missions will expand our existing global Earth observation system and push the boundaries of our knowledge in space science.

16. Recently some of your International Space Station partners expressed an interest in getting China to join the ISS program. Do you believe that the Europeans, the Japanese and your other international partners will seek to continue increasing their engagements with China in the future?

    Answer: All of NASA's International Space Station (ISS) partners have some form of cooperation currently underway with China unrelated to the ISS. While some partners have publicly expressed a desire to expand cooperation with China to perhaps include the ISS program, no partner has proposed to the ISS partnership any specific initiatives on ISS that would call for Chinese involvement of any kind.

17. The language in the fiscal year 2012 bill allows NASA to engage in bilateral activities with China only if certain certifications and notifications can be made to the Congress. OSTP, who is bound by the same language, has already submitted a certification and notification of intent to engage in bilateral negotiations with China later this spring. Does NASA have any expectation that you will submit certifications to engage in a bilateral activity with China this year?

    Answer: Currently, there are no NASA plans to submit a certification to engage in bilateral activity with China.

ISS Research

18. When do you expect CASIS will award its first grants for research in the National Lab portion of the ISS? How quickly do you think CASIS can achieve full utilization of the National Lab?

    Answer: CASIS has planned to release its first research solicitation by the end of calendar year 2012. First grant awards could reasonably be expected in the first half of 2013. CASIS has a challenging research development plan. It aims to stimulate research sponsored by non-Government funding sources, in addition to other Federal agencies. If successful, this will establish a foundation for the development of microgravity applications in low-Earth orbit. However, it should be expected to require several years to build a network of researchers and investors.

19. What are your expectations for how CASIS will balance research activity on behalf of for-profit enterprises, academia and other Federal agencies in the National Lab portion of the ISS?

    Answer: CASIS has proposed to use an economic valuation model to establish priorities for research. In its successful proposal to the cooperative agreement notice, CASIS indicated that it could apply its valuation methods to Federally sponsored research by establishing an economic value for the consequences of individual research projects. Merits of the science will be considered along with other factors in the evaluation process. NASA will be working with CASIS to assess the results of its valuation methods, to ensure that the priorities that are produced are reasonable, and provide a sensible balance between the participating communities.

Cost Control

20. Year after year, GAO continues to identify the same problems with NASA's management of large projects. Specifically, GAO cites NASA's continued approval of projects that don't meet sufficient technical maturity standards and for which design requirements have not been locked down. What is NASA doing to address these findings, and why hasn't more progress been made?

    Answer: For more than a decade, NASA has instituted through Agency policy a widely practiced systems engineering and project management process that requires rigorous knowledge-based design reviews that feed information to NASA's decision makers. This systematic approach is based on meeting industry-standard Technology Readiness Levels, extensive analysis and where possible relevant testing. In recent years, NASA has emphasized adequate formulation allowing for additional engineering analysis and testing to reduce risk and provide for establishment of more realistic commitment baselines (cost, schedule and technical). This shift has yielded greater programmatic success that we expect to continue. JUNO and GRAIL are two recent projects that were delivered in accordance with NASA's commitments. LDCM is also on track to deliver within NASA's commitment. These projects demonstrate positive results from NASA's continuous improvement efforts.

    Although NASA questioned the robustness of using percent drawing release as an effective sole indicator for design maturity as recommended by GAO, NASA concurred with GAO's recommendation and has coordinated with GAO to establish a more consistent approach to assess design stability and maturity. NASA is implementing a multi-step process to establish consistent leading indicators. First, to address the immediate need NASA published an interim directive to NASA's systems engineering processes and requirements policy on March 13, 2012. This interim directive requires use of a consistent set of three parameters (mass margin, power margin, and closure of life cycle review action items) that will be assessed monthly beginning in a project's preliminary design phase and ending in the systems integration, test and launch phase. Second, NASA is enhancing the entrance and success criteria for life cycle reviews to further account for product maturity. The revised entrance and success criteria will be documented in the revision B to NPR 7123. NASA anticipates the full revision to NPR 7123 will be completed within a year. NASA is also in the process of identifying a more comprehensive set of common leading indicators. These leading indicators were identified and substantiated from a variety of sources including: (1) a set identified by renowned leaders from the program management, project management, and systems engineering communities; (2) research performed by world-wide professional associations including the International Council on Systems Engineering (INCOSE) and the Program Management Institute (PMI); (3) the Defense Acquisition University (DAU), and (4) academia. This extended set of common indicators has been piloted on two projects and is being extended to additional projects within the agency to refine them and to assess for broad applicability. Finally, NASA has identified additional indicators that are appropriate to some but not all projects. NASA intends to include these mission unique indicators in guidance documentation. Applicability to individual missions will be determined early in formulation and tracked as appropriate throughout the life cycle.

Launch Services

21. The failure of a Taurus XL rocket during last year's Glory launch and the retirement of the Delta II rocket have left NASA without a certified medium class launch vehicle in production. Until the XL's problems are solved or a new vehicle is certified, NASA is largely limited to the small number of Delta II's remaining in stock. Do you feel confident that you will have another certified option available by the time you need it? How is the limited number of options available in the interim affecting the budgets of your medium class missions?

    Answer: NASA/Launch Services Program (LSP) is actively working with industry to develop a realistic certification plan for the next generation of medium-class launch vehicles. The total future cost impact of any new or recertified launch vehicle is not yet known. However, NASA has requested to realign funding to accommodate the increased cost associated with the available medium class launch vehicle options. In the FY 2013 President's Budget request NASA presented a funding allocation for SMAP (to launch in November 2014) and OCO-2 (to launch in the second half of CY 2014). NASA considered the range of possible viable launch vehicles that were compatible with these missions and likely to reply to the currently open solicitation. A NASA Request for Launch Services Proposals specifically including launch vehicles for OCO-2 and SMAP was released in February 2012. NASA also reviewed the Not To Exceed (NTE) costs for those vehicles that are included in the NASA Launch Services-II (NLS II) contract. The Agency budgeted for the launch vehicles with some conservatism for the expected largest final cost. The evaluation of received proposals will determine if any additional budget adjustments are required.

22. Launch vehicle costs have been rising across the board due to a number of factors, including uncertainty in both the civil and military launch markets. What steps are you taking to contain costs and realize savings over the launch prices contained in the NLS-II contract?

Answer: In March 2011, NASA signed a memorandum of understanding with the Air Force and National Reconnaissance Office (NRO) to coordinate launch requirements in order to create a stable, predictable Evolved Expendable Launch Vehicle (EELV) production rate and to alleviate concerns about industrial base capabilities and costs. In October 2011, NASA, the Air Force and the NRO also signed a coordinated strategy for certifying new entrant launch vehicles, including EELV-class launches. Based on the terms contained within the NLS II contract, any price reductions resulting from the Air Force's proposed block buy strategy for EELV will be made available on the NLS II contract as well. The real key to containing commercial launch service costs will be competition among the commercial providers. The coordinated strategy for certification of new vehicles signed by NASA, the Air Force and the NRO will allow for eventual on-ramp and certification of new launch vehicles thus facilitating increased competition and enabling prices that will be below the NTE prices currently on the NLS II contract.

23. A recent GAO study recommended that DOD and NASA leverage their collective market power and reduce unnecessary administrative duplication by jointly negotiating for launch services. Do you believe that joint negotiations would result in lower costs for either NASA or DOD? If so, why isn't this option being more vigorously pursued?

Answer: The recommendation of the referenced GAO report was not for joint negotiation, but was instead to "assess and adopt mechanisms to ensure formal coordination of the DOD and NASA acquisition processes for awarding launch services contracts with an eye toward leveraging the government's buying power and ensuring that launch prices are competitive for all U.S. government customers . . ." The referenced section of the GAO report appeared to be primarily focused on the Evolved Expendable Launch Vehicle (EELV) system which today includes the Atlas V and Delta IV launch systems.

Coordination of the Department of Defense's (DoD's) and NASA's acquisition plans for use of the Atlas V and Delta IV launch vehicles is key so each party can take the potential use of EELVs into account during procurements. However, NASA's ability to project the certainty of use of an EELV is not as great as the DoD's. For instance, in FY 2013 through FY 2017, NASA only projects to have up to four intermediate-class scientific payloads that could potentially be flown on an EELV; however, the competitive process, budget uncertainty and other factors make it difficult for NASA to commit to a large number of EELVs in advance. NASA will continue to work with our colleagues in the Air Force and the NRO to keep DoD informed of our launch service acquisition plans so the DoD can factor that information into its planning. In March 2011, NASA the Air Force and the NRO signed a Memorandum of Understanding on Evolved Expendable Launch Vehicles (EELVs) that formalized what had been a long-standing informal process of coordination between the NASA Launch Services Program Manager and counterparts within the Air Force and NRO. And, in October 2011, NASA, the Air Force and the NRO signed a coordinated strategy for certifying new entrant launch vehicles, including EELV-class launches. As NASA identifies its launch vehicle needs through our competitive process, and if those identified needs includes EELVs, those acquisition plans will be coordinated with the Air Force and the NRO in order to maximize the U.S. government's buying power. Once the Air Force puts its new EELV Block Buy strategy in place, if there are resulting EELV price reductions, due to the NASA contract terms with ULA, NASA could also benefit from those reduced prices.

The Honorable John Culberson
Subcommittee on Commerce, Justice, Science, and Related Agencies
Questions for the Record
Hearing on FY 2013 NASA Budget Request

1. General Bolden, in your written testimony you discuss the National Research Council's review of NASA's Draft Space Technology Roadmaps, which was released on February 1. This report identifies sixteen top-priority technologies necessary for NASA's future missions, which also could benefit American aerospace industries and the nation. You said that "this NRC assessment will help guide NASA's technology priorities in the years to come."

   One of the technologies the NRC emphasizes is Thermal Management Systems (TMS), which it deemed "mission critical for all human and robotic missions that require planetary entry or reentry." However, recent actions by NASA indicate their willingness to ignore the NRC's recommendations regarding TMS.

   In 2011, NASA HQ made the decision to close down the Atmospheric Reentry Materials and Structures Evaluation Facility, or "arc jet," at the Johnson Space Center (JSC). The JSC arc jet is one of only two arc jets in the country used to develop and certify thermal protection materials and systems for re-entry spacecraft. We believe this action is not only imprudent, but poses a high safety and mission success risk. In addition, NASA HQ has failed to present a business case that supports the decision to close the JSC arc jet for budgetary reasons.

   On February 24, nearly a month ago, 30 bipartisan Members of Congress sent a letter to you, questioning the rationale for this decision. To date, we have not received an answer. Please explain how this decision to close the JSC arc jet facility poses no risks to safety or to the development of future spacecraft, as well how the cost-benefit analysis supports this decision.

   Answer: Thermal Management Systems technologies are mission critical to NASA. Agency internal studies concluded that the arc jet ground test capability is a critical and strategic requirement for NASA to achieve its mission. The study by the Office of Chief Engineer concluded that NASA requirements for arc jet testing could be consolidated into one location having multiple test capabilities. Although the study recommended building a new single arc jet testing complex at a new location, the decision was made to consolidate and expand arc jet capabilities at Ames Research Center (ARC).

   With the prospect of long-term budget reductions, construction of a new green field arc jet complex, costing between $200-500M, while maintaining both existing arc jet complexes at ARC and JSC is not fiscally possible. A follow-on study to the OCE study proposed an alternative, a Recapitalization-While-Operating (RWO) approach. The RWO is a modular upgrade approach that maintains continuous testing capability at an existing operating site, while allowing incremental modernization of the arc jet testing complex and essential infrastructure elements at discrete project phases.

ARC was selected as the consolidation site because ARC has the current infrastructure and growth potential to support NASA's arc jet testing requirement into the future. Significant infrastructure investment is planned for ARC's current arc jet complex that is compatible with the Agency's long-term strategy of consolidation of the Agency's arc jet capabilities. The Arc Jet Study concluded that augmenting existing infrastructure at ARC is reasonable to consider as it would involve refurbishing and repairing the arc jet systems and components. As upgrading the capability at JSC to an equivalent level would require replacing most of the complex, the study concluded it would not be technically reasonable at JSC. JSC requires replacement of the arc heaters, water systems, vacuum systems, and power supply and adding tunnels; this effort would be equivalent to building a new facility.

NASA understands the risks of relying upon a single arc jet facility, and has chosen the option for a modular/multiple facility, where several test stations can be interchanged to accommodate various configurations of testing. Instead of having a single test station, as now configured, the proposed upgrade to meet current consolidated testing capabilities would include the ability to swap out modular test stations for quicker response to changing test requirement. This set up achieves a level of redundancy not currently available at either site.

NASA and DoD collaborate and share arc jet capabilities through inter-agency alliances. DoD has a similar arc jet complex at the Arnold Engineering Development Center (AEDC). NASA is being careful not to unnecessarily duplicate AEDC capabilities in the consolidated facility. Although not an exact match for NASA's requirements, the AEDC facilities could be modified in the event that NASA's capabilities are unavailable or when other national research priorities require arc jet capabilities beyond the NASA ARC site. The sharing of infrastructure will require collaboration across agencies for strategic planning and management and to ensure adequate accessibility. For at least the near future, the Boeing LCAT facility with test capabilities similar to the JSC arc jet test capability also provides a potential back up.

NASA has developed a transition plan to assure that the required agency technical capabilities are retained during an orderly shutdown of the JSC complex. The JSC facility relocation schedule will accommodate the completion of current testing in the JSC facility, and then activate the capability at ARC between test series. Once the capability is established at ARC, NASA plans to move the JSC facility to mothball status. The demolition program is planning to demolish the JSC facility in FY 2017.

The Honorable Tom Graves
Subcommittee on Commerce, Justice, Science, and Related Agencies
Questions for the Record
Hearing on FY 2013 NASA Budget Request

Commercial Crew Program

1. **How much are we paying Russia for seats to the International Space Station this year? How many seats are we buying? How much does that work out to per seat?**

   Answer: NASA has purchased six seats from Russia at the cost of $51M per seat in 2012 for a total cost of $306M. Please note that this cost is phased over multiple years.

2. **It's my understanding that costs are increasing exponentially and proving that sole sourcing results in increased costs with no innovation and less safety. Isn't it true that the factors of safety that we will require American companies to meet for crew transportations are 1 in 1000 while the Soyuz is 1 in 400?**

   Answer: The commercial crew requirement is that the overall Loss Of Crew (LOC) probability distribution for an International Space Station (ISS) mission shall have a mean value no greater than 1 in 270. Further, the LOC probability distribution for the combined ascent and entry phases of an ISS mission shall have a mean value no greater than 1 in 500. It should be noted that while NASA does not have a LOC requirement for Soyuz -- nor does NASA have a current probabilistic assessed value of LOC for Soyuz -- the vehicle has a long track record of success. NASA has not certified, and does not intend to "certify," the Soyuz for human spaceflight relative to all NASA's technical requirements. NASA continues to approve or clear its participation in each flight by maintaining knowledge and insight into the on-going Soyuz program, formally approving NASA and NASA-sponsored crewmember participation in its own Flight Readiness Review process, and by participating in the Russian General Design Review process, which is similar to the Agency's Flight Readiness Review process. The Russians are continually improving the Soyuz. For example, the Soyuz launched to the ISS in May 2012 featured improved micro-meteoroid protection.

3. **One of the objectives of NASA's commercial space program was to foster the commercial launch services market and increase the number of providers of space launch in the United States. The goal was to decrease US Government launch costs by diversifying the customer base. Achieving that goal is vital to other aspects of NASA, including the Science Mission Directorate and planetary science. We will be able to conduct more science if we can decrease the cost of launch for science payloads.**

   a. **How are you capitalizing on the commercial space program to deliver affordable launch for future science missions?**

Answer: The U.S. space transportation industry should benefit as a whole with the development of the commercial space program. An increased number of providers will enhance competition and innovation. Increased competition and economies of scale should help drive costs down throughout the industry. In addition, since the NASA Launch Services-II (NLS-II) contract contains a "most favored customer" clause, NASA is entitled to the lowest pricing offered to any other commercial or U.S. government customer for an equivalent launch service, which will benefit the Agency.

4. NASA's commercial cargo program (COTS) is delivering capabilities at a fraction of the cost that traditional NASA acquisition would have been. According to NASA's cost models, SpaceX's Falcon 9 launch rocket was designed and flown for $400M that contracts with the cost NASA estimated it would have been using a traditional government-only program of $4B.

   a. **Why can't we replicate that cost savings in other areas of NASA? Why is this program delivering such results?**

   Answer: NASA did not perform a detailed analysis to explain the significant differences between the cost estimates and SpaceX's actual costs. However, SpaceX attributed their cost efficiencies to a few primary factors: small workforce, simplified organizational complexity, and cost-effective infrastructure.

   NASA's Commercial Spaceflight programs are designed to enable the agency to handoff a particular capability (transportation of crew and cargo to Low Earth Orbit) to a nascent private market that industry is willing to invest its own funds in. The agency does take advantage of this sort of commoditization where it can (e.g. launch vehicles, production spacecraft buses, communications satellites, and other "standard" systems or components). However, these conditions do not apply to the large majority of NASA's programs where one of a kind research and development projects are undertaken. The nation expects NASA to be pushing back the frontier, and most of what NASA does has not been done before and will likely not be replicated in the same way – and so are not ripe for the sort of commoditization that made SpaceX successful.

5. **NASA's commercial cargo program (COTS) delivered capabilities at a fraction of the cost that traditional NASA acquisition would have been. I understand that NASA's cost models would have had SpaceX's Falcon 9 launcher cost $4B whereas SpaceX developed the rocket for $400M. Why can't we replicate that cost savings in other areas of NASA? And how can we capitalize on that cost savings in the science realm. How will our science missions at Goddard benefit from more affordable launch services?**

   Answer: Please see response to question #4a, above. The factors noted there are not necessarily applicable to all fields of research and development in which NASA is involved. This is particularly true in the area of science, where research spacecraft are not intended to become part of an ongoing, operational series , but are often unique, "one-off" spacecraft based around cutting-edge instrumentation. Science missions can, however, benefit from more affordable launch services, as purchasing the launch vehicle is a large percentage of a science mission's cost.

6. **Isn't it true that the commercial spaceflight program is also delivering economic benefits to the United States that go beyond NASA's capabilities? My understanding is that we are recapturing the commercial space launch market as a result of the nation's investments in commercial cargo capabilities.**

   Answer: The goal of NASA's commercial spaceflight program is to support the development of commercial capabilities to support both NASA and other users. The development of a robust U.S. commercial launch industry is anticipated to have positive downstream results as additional avenues for access to space will benefit the U.S. space industry as a whole. For example, in June 2010, SpaceX was reportedly awarded the largest-ever commercial space launch contract, worth $492M, to launch Iridium satellites using Falcon 9 rockets.

   NASA's launch services contract mechanism encourages growth in the commercial launch industry with the annual on-ramp opportunity for new vehicles/providers to propose to the contract.

7. **There is a lot of focus on relieving our reliance on Russia for access to the International Space Station, but aren't some of the participants in the commercial crew program relying on non-US hardware, including Russian engines? Looking at the participants in CCDev to date, how much of each company's hardware is made in America?**

   Answer: NASA does not have estimates of the amount of hardware produced in the United States versus the amount of hardware produced outside the United States for the CCDev2 concepts. However, while the majority of the hardware is made in America, several companies have indicated their plans to use some non-U.S. hardware, including Russian engines.

8. **Russia has suffered multiple launch failures recently due to quality control issues in their manufacturing base. Even when the Soyuz launches resume after a short break, persistent issues with a lack of oversight and a declining manufacturing base make the need for a U.S. alternative even more critical. Isn't it imperative that the US expedite the development of US commercial crew capabilities to eliminate this sole-source dependency? Why then in the President's budget request are we sending more to Russia then to US companies who can provide the same services?**

   Answer: NASA agrees that it is important that the U.S. expedite the development of U.S. commercial crew capabilities to eliminate the sole-source dependency on

Russia. The President's FY 2013 Budget Request includes significantly more for U.S. companies to develop commercial crew transportation services than it includes for purchasing Soyuz services from Russia. NASA is working diligently to support development of U.S. commercial crew services within appropriated funding levels in order to end the Agency's reliance on international crew transportation services.

9. **How will more frequent and affordable access to ISS for scientists and researchers allow better utilization of International Space Station (ISS), a $100B asset?**

Answer: The ISS, which is estimated to have cost the U.S. $51.7B (in direct dollars) through FY 2011, will benefit from frequent and affordable access to enable full utilization. Since the retirement of the Space Shuttle, upmass and downmass to the ISS for research (experiments, supplies, and specimens) has been challenging. More frequent access to ISS will enable an increased rate of research experiments to be performed and biological specimens to be returned to the Earth for analysis working toward the goal of maximizing utilization of ISS. Cargo vehicles will ensure that the laboratory facilities will be provided with research samples (and that they can be changed out); that Station research and operational equipment can be maintained and repaired; and that NASA and its Partners will be able to resupply crews and maintain the nominal six-crew complement.

Responses to written questions submitted by Senator Pryor resulting from the March 6, 2012, hearing at which Dr. Peck testified.

<u>Experimental Program to Stimulate Competitive Research (EPSCoR).</u>

NASA's budget request for EPSCoR barely keeps the doors open. Even more troubling is NASA's request for only $24M for the Space Grant program.

Just last month both Dr. Holdren and Dr. Suresh attended a workshop in this room on the EPSCoR program. Several years ago DoD ended their EPSCoR program. I am very concerned that the federal government is headed in the wrong direction with respect to funding EPSCoR.

- Is NASA's Education Program committed to funding EPSCoR and the Space Grant Program?
- What does the Congress need to do to make EPSCoR a higher priority for federal research agencies such as NASA?

ANSWER: The FY 2013 President's Budget, and notional out-year budgets through FY 2017, request $33M for the Aerospace Research and Career Development (ARCD) program, which consists of the National Space Grant College and Fellowship Program (Space Grant) and the Experimental Program to Stimulate Competitive Research (EPSCoR). The Office of Education proposes to allocate 33 percent of its funding in support of these programs.

The Aerospace Research and Career Development program strengthens the research capabilities of the Nation's colleges and universities and provides opportunities that attract and prepare increasing numbers of students for NASA-related careers. The student programs serve as a major link in the pipeline for addressing NASA's human capital strategies. The programs build, sustain, and effectively deploy the skilled, knowledgeable, diverse, and high-performing workforce needed to meet the current and emerging needs of NASA and the Nation. The research conducted contributes to the research needs of NASA's Mission Directorates and the Office of the Chief Technologist, and advances the Nation's scientific and technology innovation agendas.

Though the Office of Educations funding is being reduced to focus limited funds, NASA remains committed to advancing high quality STEM education using NASA's unique capabilities, and to leveraging our contributions with federal and other partners as they tackle the STEM challenges we face. NASA will align the activities conducted by each of these programs with the priorities identified in the five-year STEM strategic plan issued by the National Science and Technology Council's Committee on STEM Education and with the NASA Strategic Plan. The Agency will coordinate the education activities within NASA's Office of Education, Mission Directorates, the Office of the Chief Technologist, and Centers, to ensure that the educational activities are synergistic with the programs proposed to be funded in this account.

Questions for the Record

Submitted by Senator Kay Bailey Hutchison

For Administrator Bolden:

EXPLORATION

1. **Space Launch System (SLS) and Orion/Multi-Purpose Crew Vehicle (MPCV) Funding Levels: NASA's long-term future is beyond low-earth orbit. Yet, once again, we see that the proposed commitment of funds to develop the vehicles that will take NASA there is less than inspiring. In fact, the proposed funding levels for actual vehicle development for the Orion/MPCV) and the SLS are less now that the Administration has formally endorsed both programs than the amounts reflected in the Independent Cost Assessment last year and, presumably, submitted as part of NASA's request to OMB for FY 2013. How do you explain that the Administration's formal endorsement of SLS in September resulted in less money for these programs?**

   ANSWER: For FY 2012, the Congress appropriated $1.943B for SLS and associated ground systems, $15 M above the ICA profile when adjusted to include civil service labor. Also for FY 2012, the Congress appropriated $1.200B for Orion MPCV, $181 M above the ICA profile when adjusted to include civil service labor. The FY 2013 funding request for Orion MPCV represents a further increase over the FY 2013 budget estimates that were included in the ICA report. For SLS and associated ground systems, the FY 2013 request is $1,885 million, 99% of the ICA profile NASA is committed to the development of the Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV). Our budget formulation for FY 2013 took into account the FY 2012 Appropriation s. The requested funding will enable the Agency to develop, test and launch the SLS and Orion MPCV first uncrewed flight in 2017 and the first crewed flight in 2021. Concurrently, the Agency continues to aggressively pursue cost-savings initiatives to increase schedule confidence and robustness and reduce development costs.

2. **SLS Governmental Applications: The SLS is intended to provide the capability to launch and conduct missions to Asteroids, or the Moon, or Mars and other destinations for which NASA missions will be developed, but it certainly will have a capability that can be used for other purposes. What discussions are you having with other government agencies, for example, regarding potential use of the SLS in either its core configuration or in its fully-developed configuration, to meet needs they might have?**

   ANSWER: NASA is primarily focused on developing the SLS launch vehicle and the Orion MPCV spacecraft to provide the United States with a human capability to explore space beyond Earth orbit by 2021. NASA acknowledges this capability will be a national asset, one that can be used to the benefit of other national interests. With this capability in work, NASA has reached out to the science and military communities, providing estimated lift capability of the SLS launch vehicle. Potential requirements from these communities are being discussed and will continue to be assessed as the launch vehicle development progresses and more detailed capability information can be shared.

3. **SLS and MPCV Flight Milestones: During the hearing you stated that you may not talk about SLS and Orion/MPCV development as much as you may discuss Commercial Crew development, at least in part because SLS and Orion/MPCV programs are based mostly on known technology and relatively familiar, proven systems, and you have high confidence in their successful development. Later, in response to a question regarding the gap between the first expected uncrewed flight in 2017 and the first expected crew flight in 2021 by saying there were difficult challenges and uncertainties that would have to be addressed. Please explain that seeming contradiction. Is it not true that the 2021 date could be accelerated to an earlier date by the provision of sufficient funding levels, as opposed to any real concern about technological challenges?**

   ANSWER: NASA has developed an executable plan to develop the SLS and Orion MPCV systems to support the first human flight in 2021. The estimated budget to execute this plan has been phased to meet the fiscal budget requirements. This plan is based upon leveraging heritage hardware and developing new, efficient and cost-effective systems to enable an affordable and sustainable U.S.-developed human exploration capability. Exploration Flight Test-1 (EFT-1) (slated for 2014) and the first uncrewed flight of SLS and Orion MPCV (slated for 2017) are constrained by manufacturing capacity; additional funding would not accelerate these planned milestones. NASA will continually re-evaluate the projected 2021 launch date over the next few years to assess the potential for the integrated Orion MPCV, SLS, and Ground Systems capabilities to support an earlier launch opportunity.

4. **SLS Acquisition and Development Approach: The initial configuration of the SLS includes components that are heritage from the Space Shuttle and Ares programs, such as the shuttle main engines and the 5-segment booster. Please provide a description of NASA's acquisition strategy going forward for the SLS program with regard to competition for major components to ensure maximum efficiency for the program? What efficiencies is NASA expecting to gain from its experience on Ares and Shuttle? To what extent is NASA factoring these efficiencies in to its cost estimating for SLS?**

   ANSWER: NASA has been aggressive in the development of the SLS, having announced the basic architecture of the system on September 14, 2011, followed by the release of several synopses in September, October, and December, designed to support the development of different components of the system, including:

   • SLS Stages Acquisition (posted 9-28-11)
   • SLS Core Stage Engines (posted 9-28-11)
   • SLS Advanced Development NASA Research Announcement (NRA) (posted 3-20-12)

• SLS Advanced Booster Engineering Demonstration and/or Risk Reduction NASA Research Announcement (NRA)(posted 2-9-12)

As directed in the NASA Authorization Act of 2010, the Agency acquisition strategy is to utilize Ares I and Shuttle contracts to the extent practicable, leveraging the existing Design, Development, Test and Evaluation (DDT&E) activities and hardware. In many cases, the DDT&E efforts directly support the SLS system development thus reducing the development time. Contract changes have been approved to support the 5-segment boosters, SLS engines and development of the core and upper stages by modifying the scope of existing contracts. NASA has taken an aggressive stance on reducing costs at NASA Centers and at prime contractor locations. The number of requirements to develop the SLS launch vehicle has been reduced, providing a reduction in development and future operating costs as compared to the Ares and Shuttle programs. In an effort to reduce fixed costs, the SLS Program has worked diligently with industry partners to reduce overhead and right-size design, manufacturing and testing efforts. Finally, the SLS Program has released two competitive solicitations to reduce risk and increase future competition on the SLS Program; the Advanced Engineering Demonstration and/or Risk Reduction NASA Research Announcement (NRA) and the SLS Advanced Development NRA.

5. **SLS and Orion/MPCV Funding Profile: In the fiscal year 2013 budget proposal, the requested funding for Orion/MPCV and SLS are flat from 2014 through 2017. This draws into question how the budget is phased over these years with respect to the work that needs to be accomplished and what a typical development funding profile looks like. The FY 2013 budget request also indicates at least a $250 million decrease in vehicle development funding from the prior combined levels for these two programs. How can we be sure this planned reduced budget will not negatively affect the first combined launch of the Orion/MPCV and core elements of the SLS in December 2017?**

   ANSWER: NASA has implemented an executable plan to develop the SLS and Orion MPCV systems to support the flight in 2017 and the first human flight in 2021. This plan was developed to meet those critical milestones within the assumed flat-line budget. This plan is based upon leveraging heritage hardware and developing new, efficient and cost-effective systems to enable an affordable and sustainable U.S.-developed human exploration capability. An independent cost assessment of the plan was conducted last year, and the results validated the credibility of the plan in the near term. As the development of the SLS, Orion MPCV and ground systems continue to progress, the Agency will continue to aggressively assess the technical, schedule, cost and risk of those systems to ensure a successful first test launch of the SLS/Orion MPCV system in 2017.

6. **Baseline Cost Estimates: GAO recently reported that NASA will not be able to provide a baseline life-cycle cost estimate for SLS and Orion/MPCV until February 2013 when it expects to have greater clarity of the issues surrounding integration of these two programs. What steps are NASA taking to ensure that the cost estimate for the project is realistic and phased appropriately to ensure success in meeting the**

direction for human spaceflight outlined in the 2010 NASA Authorization Act? Please explain the basis for confidence NASA has in moving forward with these development activities in the absence of a credible baseline cost and schedule estimate for this program?

ANSWER: As stated in the previous response, NASA has developed an executable plan for meeting the direction for human spaceflight outlined in the NASA Authorization Act of 2010. This plan has been validated by an independent assessment and has been deemed credible and serviceable in the near term. During the current fiscal year, a number of significant Agency and Program reviews have either been completed or will be completed that will provide more clarity and confidence in the plan. The Exploration Systems Development (ESD) portfolio successfully completed the cross-program systems requirements review in December, enabling the SLS, Orion MPCV and ground systems programs to continue moving forward with their individual requirements development, design definition and systems development. Each of the programs has major reviews either underway or planned for this summer. Once these program reviews are complete, ESD will conduct a cross-program systems definition review to ensure all of the programs are properly aligned from a technical, cost, schedule and risk perspective. Additionally, ESD is currently performing a detailed budget assessment based upon the President's FY 2013 budget request. This detailed assessment, in conjunction with the aforementioned reviews, will enhance the basis for confidence to continue the successful development of the Exploration architecture.

7. **International Partners:** What is the current status of discussions with potential international partners for joint activity in pursuing long-term future exploration goals, including, for example, such questions as using European elements in the service module portion of the Orion/MPCV crew exploration vehicle?

   ANSWER: NASA has continued to build and strengthen international partnerships to meet the greater challenges of human exploration including future long duration missions. In addition to the on-going research being conducted on the International Space Station (ISS) among the ISS partnership, discussions are underway to explore how the ISS can be most effectively used as a testbed for long duration missions. In parallel, the International Space Exploration Coordination Group (ISECG) space agencies are coordinating an international effort to define technically feasible, programmatically implementable, and sustainable exploration pathways beyond low-Earth orbit (LEO). As a result, significant progress has been made and there is now a consensus among NASA and the participating ISECG agencies that the next steps for human exploration include sending humans beyond LEO to destinations such as near-Earth asteroids, the Moon, and eventually Mars. In preparation, it is important to maximize the use of the ISS as a unique space-based research and technology testbed. Specific international cooperation with NASA in its beyond-LEO exploration architecture will be defined as NASA's human space exploration strategic planning and analysis advance, and specific near-term opportunities for the SLS and Orion MPCV, as well as technology demonstrations, will be explored as these programs develop.

COMMERCIAL CREW DEVELOPMENT

8. <u>Commercial Market Potential:</u> **Please provide details regarding who, other than the US or other government, can be expected to buy crew launch capacity from the commercial carriers you are currently paying to design commercial human crew launch capacity? Is this market big enough for multiple commercial crew companies? Please provide specific projections justifying your conclusions and a detailed basis for those estimates.**

   ANSWER: On April 27, 2011, NASA submitted to Congress, "Commercial Market Assessment for Crew and Cargo Systems Pursuant to Section 403 of the NASA Authorization Act of 2010 (P.L. 111-267)". This report assessed the market for commercial crew and cargo services, ranging from space tourism to research and development to national interests. Over time, the commercial markets identified in this report hold the strong promise of significantly more customers, more flights, and potentially lower prices to the U.S. Government.

9. <u>Prioritization of funding:</u> **As noted previously, NASA's proposed FY 2013 budget includes a significant reduction in vehicle development funding for the combined Orion/MPCV and Space Launch System, while also proposing a $423 million increase in funding for commercial crew development, well above the amount authorized for FY 2013. Both programs have been given equal priority in the agreements between the Congress and the Administration reached last year. Please explain this decision to decrease Orion/MPCV and SLS vehicle development to levels even below what had been presented for the Independent Cost Assessment conducted mid-year in 2011, coupled with the dramatic requested increase in funding for the commercial crew program.**

   ANSWER: Please see responses to questions 1 and 3 vis. SLS and Orion MPCV. During the FY 2013 budget development process, NASA strove to strike the right balance among all our human spaceflight capabilities. The $830 million requested for the Commercial Crew Program was believed to be the amount necessary in FY 2013 to achieve safe, reliable, cost effective ISS crew transportation capability by 2017. As the primary means to U.S. access to the ISS, NASA wanted to take all steps necessary to provide assured crew access to the ISS and to eliminate our sole reliance on foreign systems.

<u>Commercial Crew Acquisition Strategy:</u> **NASA's budget documents indicate that in the transition from the Space Act agreement phase to a certification phase for Commercial Crew development, NASA will have to "accommodate redesign as necessary to ensure compliance with agency requirements".**

10. **What is NASA doing to minimize the potential for having to significantly redesign commercial partners' crew systems to ensure they meet agency requirements? Does NASA have an estimate as to how much it might cost to ensure compliance? Do the savings presented by using a space act agreement outweigh the lack of insight and oversight provided by a space act agreement?**

ANSWER: NASA plans to use a Federal-Acquisition-Regulation- (FAR)-based contract for certification of commercial systems prior to flying crew on these systems. NASA intends to structure the certification phase following the Commercial Crew Integrated Capability (CCiCAP) effort to permit the Agency to fully evaluate the proposed systems and accommodate any necessary redesign to ensure compliance with NASA safety, performance, and mission success requirements. The provider(s) awarded a certification contract will not only be required to meet the NASA requirements in order to fly NASA personnel, but they will also have to show verified compliance of how the design and hardware will meet these requirements. Thus, there will be no reduction in the safety expectations or requirements as a result of this change in acquisition strategy.

Delaying the use of FAR-based contracts will prevent NASA from mandating compliance with certification requirements during the next phase of SAAs. However, NASA will address this issue in several ways. First, NASA has released the baseline set of safety, performance, and mission success requirements to all of industry. NASA also has made these requirements available to all providers as reference under the CCiCAP effort. Although compliance with these requirements is optional for industry under a funded SAA, NASA anticipates that providers will use the NASA requirements to inform their development activities, thereby reducing the technical risk associated with the lack of NASA oversight under an SAA. Because NASA plans to have more than one company in the next phase of SAAs, we believe the competitive environment provides strong incentive for the companies to align with NASA's certification requirements in order to remain competitive in the future certification and services phases.

Third, NASA included an "Overall Safety Goal" in the CCiCAP Announcement for Proposals (see page 3 of the Announcement) which states:

"Successful commercial human space flight demands the highest commitment to safety; therefore NASA has the goal of fostering a safety culture in the commercial space flight industry that ultimately will minimize the risks associated with human space flight to LEO. NASA's goal is for Participants to demonstrate safety processes that include strong inline checks and balances, healthy tension between responsible organizations, value-added independent assessments and appropriate data archival, which will increase Government confidence in the Participant's approach to safety."

As a result, NASA will have increased insight into the providers' approach to safety during CCiCAP as the providers meet their milestones associated with the CCiCAP agreements.

11. **Is NASA comfortable that the level of insight and oversight during this critical phase of development is sufficient to provide the government with information it needs to eventually certify a vehicle and ensure obtaining the best price possible when buying commercial crew services?**

ANSWER: NASA is comfortable with the level of insight and oversight currently planned for the CCiCAP development phase. In addition, our partners have a complete list of the NASA safety and performance requirements to which their crew transportation systems will be certified. The next phase of the plan calls for crew transportation system certification activities to be conducted using a FAR based acquisition.

12. Impact of Funding Levels Less than Requested: **Please describe the impact on the commercial crew program should Congress decide to continue funding the program at or near the level appropriated for FY 2012. Provide anticipated impacts for each of several potential funding levels in $100M increments less than the requested amount, to an amount equal to the FY 2012 appropriations level. Include in those projections the impacts on anticipated timeframe for achieving the first commercial crew flight to the International Space Station, and what specific steps the program would need to take to adjust to these respective funding levels.**

ANSWER: NASA has not performed an assessment of impacts of lower than requested funding levels in FY 2013. During the FY 2013 budget development process, NASA strove to strike the right balance among our human exploration capabilities. Based on the many needs in FY 2013, the Agency submitted a request for $830M for FY 2013 for the Commercial Crew Program. This amount was believed to be the amount necessary in FY 2013 to achieve safe, reliable, cost effective crew transportation capability likely by 2017 (although earlier availability of services is not precluded).

13. Commercial Space Regulations: **Eventually, commercial space flight activity may be regulated, at least in part, by the FAA. As you know, there is currently a moratorium on FAA issuing such regulations. To what extent is NASA planning to facilitate or participate with FAA in the preparations leading to formulation of commercial space regulations?**

ANSWER: Both NASA and the Federal Aviation Administration (FAA) envision a state where the FAA licenses commercial human spaceflights provided by a robust industry, from which NASA and the private sector can purchase transportation services. The FAA has already developed processes and procedures for licensing and regulating commercial space activities to protect the safety of the public. NASA and FAA have complementary and interdependent interests in ensuring that commercially-developed human-rated systems and vehicles for low-Earth orbit are effective and safe. Both agencies seek to avoid conflicts between their requirements or duplicating each other's roles. NASA and FAA will be working together to ensure that commercial providers are subject to a coordinated and complementary set of requirements and regulations when providing services to NASA.

ISS NATIONAL LABORATORY

14. Non-NASA Research: **As you know, the Congress has designated the U.S. Segment (including bartered assets in partner-provided facilities) of the International Space Station as a National Laboratory. It has essentially divided that segment into two**

halves, operationally, and required the establishment of a Cooperative Agreement with an independent entity, organized specifically for the purposes of managing non-NASA research in the fifty percent of the U.S. segment allocated to it by law. As you know, this activity has been slow in getting put in place. Can you bring the Committee up to date on the progress in getting research up and running in the non-NASA portion of the National Laboratory?

ANSWER: CASIS has made significant progress in establishing its research program. It has appointed an Interim Chief Scientist, Dr. Timothy Yeatman, who has extensive experience in biomedical research and in industry, and an Interim Scientific Collegium. The interim Scientific Collegium members include:

- Leroy Hood, M.D., Ph.D. • President/Co-founder Institute for Systems Biology • Member, National Academy of Science, National Academy of Engineering, Institute of Medicine and National Inventors Hall of Fame (Also invented the DNA sequencer/synthesizer) • Founder of 14 companies including Amgen, Applied Bio systems and Integrated Diagnostic

- Walter Chazin, Ph.D. • Professor, Biochemistry and Physics Vanderbilt University • Director, Center for Structural Biology and Ingram Professor of Cancer Research • Instrumental in the development of structural biology and molecular biophysics (involves complementary application of different structural approaches including spectroscopy, scattering, crystallography and microscopy) • Research focused on multi-protein complexes, 3-D structures and characterization of binding interfaces/interactions

- Arnold Levine, Ph.D. • Professor, Institute of Advanced Study, Princeton University • Professor, Department of Biochemistry, Robert Wood Johnson Medical School • Former President and CEO of Rockefeller University • Recipient of American Cancer Society Medal of Honor • Co-Discoverer of p53 tumor suppressor gene

- Torben Orntoft, Ph.D. • Head, Department of Molecular Medicine, Aarhus University, Denmark. • CEO of AROS Applied Biochemistry • Member, European Academy of Cancer Sciences • Member, Scientific Advisory Board, Novo Nordisk • Research focused on identification of molecular biomarkers for use in disease classification and prediction

- Jeffrey Trent, Ph.D. • President, Translational Genomics Research Institute • Founding Scientific Director, Intramural Research for the Human Genome Research Institute, NIH • Member, multiple commercial company scientific advisory boards.

The Interim Scientific Collegium has reviewed past NASA-sponsored research in biology and biotechnology and has identified several areas of initial interest. The group has consulted with major pharmaceutical companies to determine market potential. CASIS has structured its first research solicitation, planned for release this June, around the findings of the Collegium.

15. <u>National Lab Designation:</u> **One of the driving factors in the National Laboratory designation—and especially in the requirement for an independent entity to manage half of the research conducted in the U.S. Segment was to ensure that research planned for the station would not be subject to changes in NASA research requirements and priorities. What are you doing to ensure that the independent entity with which you have a Cooperative Agreement actually remains independent and free from those kinds of changes in NASA priorities?**

    ANSWER: Under the cooperative agreement, CASIS is free to work with NASA whenever CASIS's objectives will benefit from access to NASA facilities or capabilities. However, NASA has no control or influence on the research directions chosen by CASIS. All of the NASA personnel responsible for communication with CASIS understand this principle. CASIS has not been asked to coordinate its research with NASA, or to align its objectives with NASA priorities, other than to fully utilize the ISS by conducting significant, highly meritorious research.

16. <u>National Lab Research Processing:</u> **One purpose of the independent National Laboratory management role is to ensure equal opportunity for Principal Investigators to prepare and submit research proposals to, in effect, compete for access to the resources of the ISS National Laboratory. To enable the preparation of those research proposals, the underlying "rules" of the proposal and selection processes must be published and available for information and understanding of the criteria that will serve as the bases for selection. Have these "rules," or guidelines and procedures been established, disseminated and explained by the Independent management entity? If not, what is the expectation of the availability of that information? What role has NASA played or will it expect to play in the development of those guidelines and procedures?**

    ANSWER: The cooperative agreement with CASIS requires that resource prioritization decisions be made "...using a fair, transparent, and impartial selection process that maximizes value of the ISS investment made by the Nation." The valuation framework that will be employed to determine the merit of competing projects is one of the third quarter deliverables identified in the 2012 Annual Program Plan.

17. <u>ISS Logistics and Supportability:</u> **What is the impact of the latest delay of the first mission of SpaceX's Falcon 9 to the ISS on the utilization of ISS given that initial planned milestones have been delayed and GAO reported as late as November 2011 that SpaceX was scheduled to fly 3 fully operational resupply missions to the ISS in 2012? At what point, without augmentation from planned commercial cargo delivery capability, will the ISS begin to experience shortfalls in the necessary supplies to support ISS crew and science? Please provide a timeline for such**

potential shortfalls and details regarding NASA and its partners' contingency response should they be experienced.

ANSWER: On May 22, 2012, SpaceX launched its second COTS demonstration flight, and three days later, the Dragon spacecraft was berthed to the ISS. The mission, which accomplished the remaining COTS demonstration goals for SpaceX, was brought to a successful conclusion on May 31, with the deorbiting and splashdown of the Dragon capsule. NASA expects Orbital to complete the on-orbit COTS demonstration to ISS this year.

NASA anticipated a delay in CRS resupply services and has adequately provisioned the ISS with maintenance, operational and utilization support cargo to sustain a delay into 2013. NASA is currently working with SpaceX and Orbital to complete the first CRS flight in FY 2012 and four additional flights in FY 2013. NASA is also working with its International Partners to prioritize utilization cargo over other cargo if necessary to meet our utilization goals. Given that the ISS is continually being resupplied by the Partner vehicles, Progress, ATV and HTV, and that the CRS missions are expected to begin in the summer/fall timeframe of this year, NASA does not expect shortfalls in utilization.

JAMES WEBB SPACE TELESCOPE (JWST)

18. **<u>JWST Funding Impact on Other Programs:</u>** We have agreed on the importance of moving forward with the JWST program. However, with a constrained to-line funding level for NASA, the replan for the JWST project has meant that tough decisions had to be made at the expense of other projects and activities in the 2015 through 2018 time frame. Can you outline what projects and activities in NASA's portfolio were terminated or scaled back to accommodate the JWST project's lifecycle cost increase? Additionally, what other constraints is the agency dealing with due to the JWST delay, such as test facility access, and how is the agency addressing these issues to minimize the impact on other ongoing projects?

    ANSWER: NASA's FY 2013 budget request identifies four key priorities to be funded in this constrained fiscal environment: ISS sustainment and utilization using commercial crew and cargo services; Space Launch System and Orion Multi-Purpose Crew Vehicle; JWST; and new technologies. In view of these four key priorities for NASA (not just JWST) and of our constrained fiscal environment, we will not be moving forward with the 2016 and 2018 ExoMars missions that we had been studying with the European Space Agency. Instead, NASA is developing a new, integrated strategy for Mars missions to ensure that the next steps for Mars exploration will support science, as well as longer-term human exploration goals, and take advantage of advanced space technology developments. NASA will complete this integrated plan, including the framework for a mission to take advantage of the 2018 or 2020 launch opportunities, no later than this summer. In addition, NASA is slowing the ramp-up of some current science projects and delaying the start of some future ones, such as slowing the rate of solicitation for new competed missions, in the notional outyear budget projection in the FY 2013 Budget. Finally, NASA will be unable to initiate development of the highest priority new large mission recommended by the NRC's 2010 Astrophysics decadal survey—the Wide-Field

InfraRed Survey Telescope (WFIRST) until JWST development is largely complete. With regard to test facility access, NASA is actively managing the movement of JWST, the Magnetospheric Multiscale (MMS) mission, and the Global Precipitation Measurement (GPM) mission through the available facilities given their overlapping schedules, and we have resolved the schedule conflicts in a manner that removes the pressure of requiring multiple missions to have perfectly timed entrance and exit from difficult testing periods. In so doing, we have minimized the risks to all three missions. It is important to note that this situation was not driven solely by the delay in JWST development, as MMS and GPM have also had internal schedule challenges.

MISCELLANEOUS ISSUES

19. **<u>Astronaut Selection:</u> NASA recently reported a record number of astronaut applications even though the size of the astronaut office is less than half the previous number of positions before the end of the Space Shuttle program. What do you believe is driving that? Can you provide for the record a summary of the stated reasons given by the applicants for this high level of interest?**

ANSWER: Being an astronaut is an aspiration many people have their entire lives, and this response indicates that many thousands would love to be a part of our continuing human spaceflight program as part of the Astronaut Corps.

Since we do not have a survey mechanism as part of the application process, there is no way for us to know for certain why so many people applied this year. We feel the dramatic increase in applicants for this application window is likely due to any combination of factors – including the high-visibility of NASA in the news as we transitioned from the space shuttle to International Space Station and a redesigned USA JOBS application process.

The agency executed a comprehensive communications campaign to ensure the public knew about this opportunity. The public affairs team not only utilized traditional communications techniques and mainstream media, but also capitalized on social media channels (such as Twitter, YouTube, Facebook and blogs) to raise awareness of this job opportunity. The agency also encouraged employees and astronauts to share information via their own personal and professional networks and at speaking events and appearances, created Public Service Announcements (PSA's) that were made available online for radio and television use, and reached out to all branches of the U.S. military to ensure they had information they could share with their members.

20. **<u>Mars Exploration Program:</u>** This Budget has raised concerns in the planetary science and international space community about the reductions in planned Mars Exploration programs. Can you address those concerns, and explain how you intend to reaffirm the country's interest in these programs—and our reliability as an international partner in future joint cooperative missions?

ANSWER: The NASA Administrator has directed the Associate Administrator for the Science Mission Directorate to lead Mars program reformulation activities working with the Associate Administrator for Human Exploration and Operations Directorate, the NASA Chief Technologist, and the NASA Chief Scientist. In support of this reformulation, NASA has established a Mars Program Planning Group (MPPG), to develop options for a program-level architecture for robotic exploration of Mars that is consistent with the President's challenge of sending humans to orbit Mars in the decade of the 2030s, responsive to the primary scientific goals of the 2011 NRC Decadal Survey for Planetary Science, and consistent with the President's FY 2013 budget request. The MPPG is expected to identify potential investigations and options in sufficient detail for NASA to be able to select and initiate high pay-off mission(s) beginning with the 2018 launch opportunity, and to facilitate NASA's decision-making process for a reformulated Mars Exploration Program. In concert with the Mars Exploration Program the MPPG will communicate with customers, stakeholders and partners to ensure a collaborative and responsive set of investigations and options, This process will inform NASA's development of its FY 2014 budget submission.

We plan to actively engage ESA and the Canadian Space Agency in the next few weeks, seeking their input and engagement with the Mars Program's reformulation as early as practicable. We also intend to engage the broader international community in May through the established International Mars Exploration Working Group (IMEWG), an ad hoc organization of Space Agencies that was formed in 1993 to facilitate coordination among the world's Mars-faring nations.

NASA has a long history of very successful cooperation with nations around the world, and a part of that history has from time to time included some decisions by NASA and some by our international partners to re-phase or re-design or even terminate planned cooperative activities. Our partners are very aware that in all instances our cooperation is based on the availability of appropriated funds, just as we are aware that their participation has similar funding constraints. Consistent with the National Space Policy and the Space Act, NASA will continue to pursue international cooperation in support of its activities and mutual objectives. Currently, NASA has over 500 active agreements with over 100 countries and anticipates that international cooperation will remain a cornerstone of all of its future activities.

21. **Alternative Mars Exploration Planning Activities:** During the hearing you said, regarding Mars Exploration program future planning, "However, we are now developing a new integrated strategy for Mars missions to ensure that the next steps to Mars exploration will support the science objectives that were laid out in ExoMars, the priorities established by the National Research Council's decadal survey on planetary science, and also support our human exploration." Please provide your timetable and details on how you are developing this new integrated strategy. Lessons Learned: Historically, many NASA projects have experienced cost increases and schedule delays, whereas the GRAIL and Juno projects both launched on schedule and are currently within budget. What practices or procedures allowed these projects to meet their baseline? To what extent are lessons from those programs applicable—and being applied—to a broader array of NASA program activities?

ANSWER: As noted above, NASA has established a senior leadership team focused on reformulating the Mars program and has set up a Mars Program Planning Group (MPPG). The MPPG will develop options for a program-level architecture for robotic exploration of Mars that is consistent with the President's challenge of sending humans to orbit Mars in the decade of the 2030s, responsive to the primary scientific goals of the 2011 NRC Decadal Survey for Planetary Science, and consistent with the President's FY 2013 budget request. The MPPG will provide NASA with progress reports in April, June, and August. These reports will provide senior NASA leadership with decision-making opportunities to steer the MPPG in investigation and architecture options, and the Mars Exploration Program in associated budget development, culminating in a presentation of options in August. We anticipate that NASA will be able to brief the relevant Congressional Committees on progress periodically through the summer, and will be able to provide more detailed briefings on a proposed mission architecture after the release of the President's FY 2014 budget request in early 2013.

Lessons Learned: NASA's experience with managing the development of challenging, one-of-a-kind science missions has led to several lessons identified and applied to all new programs. These lessons have resulted in updates to NASA's formal procedural requirements documents for management of all NASA-developed spaceflight programs and projects. Specific steps NASA has taken include:

- Establishment of joint cost and schedule confidence level (JCL)-based life cycle cost budgeting that improves the understanding of the complexities and risks associated with a development result in more accurate estimates of cost and schedule as evidenced by the recent performance of Juno and GRAIL;
- Requirement that projects implement Earned Value Management (EVM) systems to weigh technical progress against expenditure of funds on a monthly basis provide early indicators of issues;
- Extended duration Phase B definition and preliminary design to allow for technology maturation and through system engineering to better characterize the risks to be retired during development and identify unique integration and test needs;
- Use of a formal acquisition strategy process before and during Phase A to define program management structure and Center and contractor roles in a way that best fit the project under consideration;
- Strong independent reviews at key points in the development to verify that the project is making progress per its plan and to offer additional insights based on the independent review teams experience; and,
- Regular reviews with senior NASA management to assure that project concerns are addressed quickly to avoid cost and schedule implications.

22. <u>(Launch Vehicle Access):</u> GAO recently reported that 9 major projects experienced issues with launch vehicles, including increasing costs and availability of launch vehicles. Additionally, GAO also made a recommendation in its duplication mandate report on the need for increased coordination between NASA, DOD and NRO on the acquisition of launch vehicles. Is NASA actively addressing this issue, given the impact that this issue could have on the cost of current projects? How does NASA plan to pursue coordination with DOD and NRO to increase efficiency in the acquisition of launch vehicles?

ANSWER: Yes – NASA is actively addressing both issues identified by the GAO. The first part of your inquiry is from the GAO's March 2012 report, "*NASA: Assessments of Selected Large-Scale Projects*." The GAO identified 20 programs and projects with space launch related aspects in this report. As you note, the GAO identified nine of those projects as having "launch issues." In NASA's view, six of the nine missions do not have launch issues of note since they have either already successfully launched (GRAIL & NPP); or have launch service contracts in place and are on track for launch (LADEE, MAVEN & TDRS); or are in the early stages of development (SPP). NASA agrees there are three medium-class missions with launch issues to resolve (ICESat-2, SMAP & OCO-2). ICESat-2 identified in the GAO report that launch service cost was its challenge, thus the NASA Launch Services Program (LSP) is working with the project to identify and develop launch alternatives to meet their needs in time for a CY2016 launch. SMAP and OCO-2 identified in the GAO report that launch vehicle availability was their issue. NASA's LSP recently terminated the Taurus XL launch service task order (LSTO) for OCO-2 due to the Orbital Science Corporation's inability to determine the root cause for the previous two Taurus XL launch failures. On February 3, 2012, NASA LSP released a Request for Launch Service Proposal to industry to begin the competitive process to provide a commercial launch service for SMAP and a new commercial launch service for OCO-2. Awards are expected in the July 2012 timeframe.

The second part of your inquiry is from the GAO's February 2012 report, "*2012 Annual Report: Opportunities to Reduce Duplication, Overlap and Fragmentation, Achieve Savings, and Enhance Revenue*." Section 23 of this report deals with "*Space Launch Contract Costs*" and has as its premise that "*Increased collaboration between the Department of Defense and National Aeronautics and Space Administration could reduce launch contracting duplication.*" This section of the GAO report is written specifically on the procurement of Evolved Expendable Launch Vehicles (EELVs) which are "intermediate" and "heavy" class launch vehicles provided by United Launch Alliance (ULA). NASA, together with the Air Force and NRO are already actively addressing the issue of increased coordination and we provide the following as evidence. First, the NASA Administrator meets with the Secretary of the Air Force and the Director of the NRO quarterly to discuss and coordinate activities on multiple topics of mutual interest. The formal commitment to continue our coordination efforts was put in place via a Letter of Intent that was signed by the three Agency heads in October 2010. A Memorandum of Understanding (MOU) on Evolved Expendable Launch Vehicles (EELVs) was signed by the three Agency heads in March 2011 and formalized what had been a long-standing informal process of coordination between the NASA Launch Services Program Manager and her counterparts within the Air Force and NRO. This MOU established a "*Government Expendable Launch Vehicle (ELV) Executive Board as a forum for interagency communication of acquisition, certification, and programmatic ELV launch issues.*" This forum meets on a quarterly basis and is "*the mechanism to implement the block buy strategy, baseline and modify EELV launch requirements, and enable resolution of EELV programmatic issues to provide clear direction to launch providers.*" The additional signing of the *Coordinated Strategy for New Entrant Launch Vehicle Certification* in October 2011 is further evidence of our close work together for launch service acquisition. As NASA identifies its launch vehicle needs through our competitive process, and if those identified needs includes EELVs, those acquisition plans will be coordinated with the Air Force and the NRO in order to maximize the U.S. government's buying power.

23. **Education Program Reductions:** The proposed Education budget is down approximately 30 percent. How will NASA further our scientific advancement and contribute to our economic and technological viability and competitiveness if it is unable or unwilling to invest in educating our nation on the advantages and benefits of Science, Technology, Engineering and Mathematics? What steps are you taking to ensure NASA can continue to make an important contribution in this area?

ANSWER: NASA brings many assets to support the Administration's emphasis on science, technology, engineering and mathematics (STEM) education beyond funding. Our people, platforms like the International Space Station, and our facilities across the Nation all contribute to strengthening STEM education. Though funding is being reduced in alignment with the Administration's priority on focusing limited funds, NASA remains committed to advancing high quality STEM education using NASA's unique capabilities, and to leveraging our contributions with federal and other partners as they tackle the STEM challenges we face. NASA will align its funding on the priority STEM issues identified by the National Science Technology Council (NSTC) Committee on STEM Education through grants, cooperative agreements, internships, fellowships and other hands-on experiences for learners, educators and institutions.

The FY 2013 request is $100.0M, a $38.4M or 28 percent decrease from the FY 2012 request ($138.4M) and the FY 2012 Effective Planning Level ($138.4M). The FY 2013 request includes:

- $24.0M for Space Grant, a nationwide network of colleges, universities, and other organizations that provide NASA space-related opportunities to students, educators, and the public.
- $9.0M for EPSCoR, which provides competitive research opportunities to institutions in targeted states.
- $30.0M for MUREP, which provides competitive NASA research and study opportunities to students of underserved and underrepresented groups and competitive opportunities to enhance the research and technology capabilities of Minority Institutions.
- $37.0M for STEM Education and Accountability projects, which provide competitive opportunities, foster innovative education efforts at NASA Centers and through grantees, and formal evaluation activities.

To offset some of the impacts, NASA is increasing its emphasis on strategic partnerships. The Agency currently has an open partnership announcement available at http://www.nasa.gov/offices/education/about/NASA_Seeks_Collaborators.html. NASA seeks unfunded collaborations with organizations to enhance its ability to achieve its strategic goals, outcomes, and objectives as they relate to education and as articulated in the 2011 NASA Strategic Plan. This Announcement requests information from creative organizations with wide-ranging areas of expertise interested in collaborating with NASA in reaching new or broader audiences across a national scale.

24. **Construction, Environmental Compliance and Restoration:** During these times of belt tightening, please elaborate on the justification for what new and necessary

construction or restoration NASA is funding with the proposed increase of 27 percent in this line of funding from FY 2012?

ANSWER: The 27 percent increase in Construction and Environmental Compliance and Restoration (CECR) is primarily a result of continuing program requirements which were initially identified in December 2011 in NASA's FY 2012 Initial Operating Plan, as well as requirements for the environmental clean-up effort at NASA's Santa Susana Field Laboratory site in California.

The majority of these program requirements are for Space Launch Systems (SLS) and 21st Century Space Launch Complex. Exploration did not have FY 2012 Construction of Facilities in the President's Budget as these emerging programs did not exist early in the FY 2012 budgetary process. For example, SLS was not a program until May 2011. These funding increases from FY 2012 to FY 2013 are normal and expected as the program ramps up and the requirements become more defined.

These construction projects are for manufacturing of the actual SLS flight hardware at Michoud Assembly Facility, modification of test stands for structural testing of the new SLS flight hardware at Marshall Space Flight Center, as well as, modifying launch and integration facilities at Kennedy Space Center for the new programs. While SLS is using as much of the existing infrastructure as is feasible, modifications for the new flight hardware are still required.

Senate Commerce, Science, and Transportation Committee
Priorities, Plans, and Progress of the Nation's Space Program
March 7, 2012
Senator Boxer
Questions for the Record

QUESTIONS FOR THE RECORD FOR ADMINISTRATOR BOLDEN

Planetary Science

Question 1: I understand the difficult budgetary environment we are in but I am very concerned that Planetary Science programs received a 21 percent cut in the FY 2013 budget while the proposed cut to NASA's overall budget is 0.3 percent. Why was this disproportionately large cut made to Planetary Science?

Answer 1: NASA's FY 2013 budget request identifies four key priorities to be funded in this constrained fiscal environment: ISS sustainment and utilization; Space Launch System and Orion Multi-Purpose Crew Vehicle; James Webb Space Telescope; and new technologies. In view of these four key priorities for NASA and of our constrained fiscal environment, we will not be moving forward with the 2016 and 2018 ExoMars missions that we had been studying with the European Space Agency. Instead, NASA is developing a new, integrated strategy for Mars missions to ensure that the next steps for Mars exploration will support science, as well as longer-term human exploration goals, and take advantage of advanced space technology developments. NASA will complete this integrated plan; including the framework for a mission to take advantage of the 2018 or 2020 launch opportunities, no later than this summer.
The FY 2013 budget request funds several exciting missions that will greatly advance our understanding of the solar system. These include:

- The Mars Science Laboratory Curiosity rover will land on Mars on August 6 of this year and will begin a five-year investigation in the area of Gale Crater in an attempt to determine if Mars could have been a habitable environment for life in the past;
- The Mars Atmosphere and Volatile EvolutioN (MAVEN) mission will launch in 2013 to determine the role that loss of volatile compounds (like water, carbon dioxide, and nitrogen), from the Mars atmosphere to space has played over time, giving insight into the history of Mars atmosphere and climate, liquid water, and planetary habitability;
- The Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-REx) will launch in the 2016 timeframe on a mission to return a sample from an asteroid;
- The Discovery 12 mission will be selected later this year from among three competing candidates, with the winner entering into formulation for launch in the 2016 timeframe;
- Several missions currently in operation or on their way to their distant destinations, including GRAIL at the Moon, MESSENGER at Mercury, Cassini at Saturn, New Horizons on its way to Pluto (2015), and Juno on its way to Jupiter (2016).

Question 2: The Mars missions of the past have proven very successful, the next rover is on its way, and NASA had an agreement to work with the European Space Agency (ESA) on the 2016 and 2018 Mars missions. Unfortunately, due to the large cut to Planetary Science, NASA has indicated that it will no longer participate in the next Mars missions. Are you planning to join ESA on future Mars missions? If so, in what time frame? What are the future plans for the workforce of the Jet Propulsion Laboratory (JPL) which has been working on the Mars missions? How will you maintain the core capabilities of this group so that the skills developed at this lab are not lost?

Answer 2: As you noted, due to current and future budgetary constraints and other higher Agency priorities, NASA will not be able to participate as originally planned in the Joint Mars Exploration missions conceived with ESA for 2016 and 2018. NASA had an agreement with ESA to begin study and design work for the2016 and 2018 missions, but had not yet executed a follow-on agreement for full mission implementation. If the European missions go forward, NASA will likely support ESA in some manner. We continue to have mutual interests in the exploration of Mars, and we anticipate and hope that NASA and ESA will find new opportunities to collaborate. NASA has established a Mars Program Planning Group that will initially focus on a NASA Mars robotic mission in the 2018-2020 timeframe. We plan to actively engage our bilateral partners from ExoMars, namely ESA and the Canadian Space Agency, in the next few weeks, seeking their input and engagement with the Mars Program's reformulation as early as practicable. We also intend to engage the broader international community in the near future through the established International Mars Exploration Working Group (IMEWG), an ad hoc organization of Space Agencies that was formed in 1993 to facilitate coordination among the world's Mars-faring nations.

Landing large masses on the Martian surface remains a necessary part of any strategy for Mars exploration. Therefore, while a loss of some skilled personnel after the landing of the Mars Science Laboratory is anticipated, NASA will work to retain critical skills and capabilities sufficient to sustain our skills in entry, descent, and landing prior to the next landed mission to Mars. The total JPL workforce is currently slightly over 5,000, down by several hundred over the last several years. JPL's current best estimate is that the workforce can be maintained in FY 2012 at about 5,000 but may need to be reduced by approximately 300-400 in FY 2013. A reduction of that scale (6%) could be largely handled through attrition. Some mitigation of the losses may occur through a new Mars mission for the 2018/2020 opportunity in the restructured program, and the fact that JPL is working on one of the three currently competing Discovery mission proposals. JPL is also forecasting an increase in non-NASA work. The current uncertainties should diminish over the rest of this year.

Commercial Space

Question 3: In its FY 2013 request, NASA is seeking a total of $830M for the Commercial Crew program. Last year, as you know, Congress appropriated $406M for the program, about $100M less than the authorized level. How will the requested amount enable NASA and the Commercial Crew providers to close the U.S. human spaceflight gap more quickly?

Answer 3: NASA's original request for the Commercial Crew Program was:

($ in millions)	2011	2012	2013	2014	2015
FY 2011 BUDGET	500	1,400	1,400	1,300	1,200

With this budget, NASA estimated that a commercial crew capability could be in place by 2015. However, the amount appropriated in 2011 was $312 million ($188 million less than requested) and NASA was precluded from initiating a "new start." Thus, NASA adjusted its strategy and initiated CCDev Round 2 which focused on maturing elements of the systems instead of overall integrated crew transportation systems. The combined impact of the lower than expected budget and shifting to focus on elements of the system instead of an integrated system was that it delayed NASA's estimated expected operational date of commercial crew to 2016.

The amount appropriated in 2012 was $406M ($444M less than the newly requested amount of $850M). This resulted in a further slippage of NASA's expected operational date to 2017. The requested funding levels in the President's FY 2013 request of $830M will support the expected operational date of 2017 for regaining U.S. human spaceflight launch and return capability to and from LEO.

NASA is planning for commercial crew capability to be in place in 2017; but the Agency's plans will not preclude earlier availability of services. Many of the potential commercial providers have stated they can have services available earlier.

Question 4: The Commercial Crew program is designed to achieve, at a lower cost, an accelerated human spaceflight capability to the International Space Station. How is maintain a competition important to the long term sustainability, cost and success of the program? Does NASA intend to maintain at least two or more competitors in order to drive innovation and provide best value to the taxpayer throughout both the development and procurement stages, as it did with the Commercial Orbital Transportation Services (COTS) and Commercial Resupply Services (CRS) program?

Answer 4: NASA believes that having multiple companies competing against each other at this stage of the Commercial Crew Program will result in lower overall costs for the Government. In a traditional program with a single prime contractor from the start using a cost-plus contract, the NASA-Air Force Cost Model (NAFCOM) cost estimates are approximately $8-11B for the development of an ISS crew transportation capability. Using the current, innovative approach of competing Space Act Agreements will result in multiple awards to industry with fixed Government costs. NASA estimates being able to cut the development costs substantially and deliver an ISS capability for around $5B. Maintaining competition is a key factor in achieving these savings.

While the Agency has not established a specific number of awardees for the next phase of the Commercial Crew Program, referred to as Commercial Crew Integrated Capability (CCiCAP), NASA plans to have fewer companies in CCiCAP than are currently in CCDev2. There are seven partners in CCDev2 (four funded and three unfunded partners). NASA would like to maintain as much competition as it can for as long as possible.

Removing competition by developing a single system from various companies' system elements would eliminate most of the commercial aspects of the program. With only one provider from which NASA could purchase services, there would be little incentive for the companies to expand their commercial market base by selling services to any other customers or to maintain reasonable prices. There would also be no incentive for the companies to share in the development costs. Having industry share in the cost of development and selling seats to other customers in addition to NASA will likely decrease NASA's costs for crew transportation services in both the short and long-term.

Question 5: Are you confident that the use of Space Act Agreements and ultimately a Federal Acquisition Regulation (FAR)-based acquisition at the end of the process will ensure that NASA's safety requirements are met in these new commercial systems?

Answer 5: NASA plans to use Federal-Acquisition-Regulation-(FAR)-based contracts for certification of commercial systems prior to flying crew on these systems. NASA intends to structure the certification phase following the CCiCAP effort to permit the Agency to fully evaluate the proposed systems and accommodate any necessary redesign to ensure compliance with NASA safety, performance, and mission success requirements. The provider(s) awarded a certification contract will not only be required to meet the NASA requirements in order to fly NASA personnel, but they will also have to show verified compliance of how the design and hardware will meet these requirements. Thus, there will be no reduction in the safety expectations or requirements as a result of this change in acquisition strategy.

NASA is addressing the issue of compliance with certification requirements in several ways. First, NASA has released the baseline set of safety, performance, and mission success requirements to all of industry. NASA also has made these requirements available to all providers as reference under the CCiCAP effort. Although compliance with these requirements is optional for industry under a funded SAA, NASA anticipates that providers will use the NASA requirements to inform their development activities, thereby reducing the technical risk associated with the lack of NASA oversight under an SAA. Because NASA plans to have more than one company in the next phase of SAAs, we believe the competitive environment provides strong incentive for the companies to align with NASA's certification requirements in order to remain competitive in the future certification and services phases.

Third, NASA included an "Overall Safety Goal" in the CCiCAP Announcement for Proposals (see page 3 of the Announcement) which states:

"Successful commercial human space flight demands the highest commitment to safety; therefore NASA has the goal of fostering a safety culture in the commercial space flight industry that ultimately will minimize the risks associated with human space flight to LEO. NASA's goal is for Participants to demonstrate safety processes that include strong inline checks and balances, healthy tension between responsible organizations, value-added independent assessments and appropriate data archival, which will increase Government confidence in the Participant's approach to safety."

As a result, NASA will have a great deal of insight into the providers' approach to safety during CCiCAP as the providers meet their milestones associated with the CCiCAP agreements.

Question 6: We heard from NASA that the Commercial Crew program is a "must have" not a "nice to have" and that the U.S. has a choice: it can invest more in U.S. commercial crew capabilities now, or spend more on Russian crew services later. How much are we paying Russia for crew transport today and over the next several years? Given recent launch failures of the Russia Soyuz and other systems, can you comment on the level of insight and oversight NASA currently maintains over Russian vehicles that carry our astronauts? How does this compare to your oversight of the U.S. companies developing new systems?

Answer 6: NASA has purchased six seats from Russia at the cost of $51M per seat in 2012 for a total cost of $306M. Please note that this cost is phased over multiple years.

In March 2011, NASA signed the most recent modification to the current International Space Station (ISS) contract with the Russian Federal Space Agency for crew transportation, rescue and related services from 2014 through June 2016. The firm-fixed price modification, valued at $753 million, covers comprehensive Soyuz support, including all necessary training and preparation for launch, flight operations, landing and crew rescue of long-duration missions for 12 individual space station crew members.

NASA has been purchasing transportation and rescue services from Russia for many years as a customer, and the Russians have proven to be consistently reliable partners. For example, in the aftermath of the Columbia accident, the Russians provided the Soyuz and Progress spacecraft necessary to keep the ISS operational. In terms of NASA's insight into technical systems and issues, the Russians have kept NASA officials very well informed regarding anomalies experienced (e.g., Soyuz ballistic re-entries, the Progress 44P anomaly). The Russian Federal Space Agency (Roscosmos) is responsible for resolving technical issues related to anomalies and coordinating with all of the International Partners, including NASA. This coordination is formally manifested in meetings of the Space Station Control Board, Multilateral Coordination Board, and ISS Mission Management Team, as well as the partners' participation in the standard Stage Operations Readiness Reviews and Flight Readiness Reviews. NASA is satisfied with this level of insight.

As noted in the response to question #5, NASA will have significant insight into U.S. commercial providers' designs during CCiCAP. When the Commercial Crew Program begins a Federal Acquisition Regulation (FAR)-based contract, the Agency will have the level of insight and interaction typical of such a contract.

Question 7: Assuming the Commercial Crew program delivers crew capability on time and on schedule, how will more frequent and affordable access to ISS for scientists and researchers lead to better utilization of ISS?

Answer 7: The ISS will benefit from frequent and affordable access. Cargo vehicles will ensure that the laboratory facilities will be provided with research samples (and that they can be changed out); that ISS research and operational equipment can be maintained and repaired; and that NASA and its Partners will be able to deliver the supplies and consumables needed to maintain the nominal six-crew complement.

NASA Workforce

Question 8: During this time of transition, strategic management of the agency's workforce poses a challenge. How is the agency planning to maintain core technical competencies as the current generation of employees retires?

Answer 8: While NASA's mission has been in a time of transition, its workforce has been relatively stable. At less than 5% attrition each year, NASA has a very low rate of attrition compared to other Federal agencies and to the private sector. Based on its workforce profile, NASA does not project an increase in the rate of retirement losses in the near- and mid-term future large enough to disrupt the planned transition of core technical competencies to workforce that will be sustained and the in-coming generation of NASA employees.

NASA plans to enhance its already robust intern programs and active recruitment of recent graduates with the coming implementation of the Pathways Program. After they join NASA, these employees have access to a wide array of training opportunities, including formal in-person and on-line training, informal on-the-job training, mentoring, and rotational or detail assignments in order to develop individual capability in the Agency's core technical competencies. On an on-going basis, employees and NASA organizations have access to an extensive knowledge management capability was well as lessons learned data bases—both designed to support the continuity of core technical competencies.

Question 9: What funds have been identified to support the strategic hiring needed to make sure that NASA's technical excellence remains second to none through the 21st century?

Answer 9: NASA's workforce FTE levels are projected to remain relatively stable in the coming years, with only modest reductions currently anticipated. This means that the current level of civil service labor funding largely will be sustained. As current employees attrit from the Agency rolls, replacement hiring will be on-going to fill key positions, and the workforce will be replenished with new talent. Given NASA's very low attrition rate and the Agency's modest FTE reductions, NASA actively makes prioritization decisions within its hiring program. "Replacement" hires are not necessarily made into the vacated position of each person who leaves—replacement FTE are more typically redirected to new or different positions; because of this process, the Agency is able to continually adapt its current high level of technical excellence to meet new mission challenges. In implementing the Pathways Program, NASA plans to significantly enhance recruitment for interns and recent graduates with the addition of new Agency-level leadership focus and activities.

International Space Station

Question 10: With the assembly of the International Space Station completed, NASA can now focus on utilizing the laboratory to continue scientific research. How much funding will go towards life and physical research in the coming fiscal years? How does NASA intend to implement the recommendations of the National Academies' Decadal Survey?

Answer 10: Please see below table showing life and physical sciences research funding in the FY 2013 budget request. The Decadal Survey provided NASA with over 60 "highest priority" research recommendations, and eight potential prioritization criteria. All of NASA's current ISS research portfolio is within the highest priority recommendations of the Decadal Survey. The NASA Office of the Chief Scientist is coordinating a NASA response to the Decadal Survey that will describe a strategy for implementing the priorities within the context of schedule and budget constraints. Within the limits of NASA's budget constraints, we will closely consider the recommendations of the Decadal Survey in decisions on investments in new research facilities and capabilities for the ISS, in a research program that balances the pursuit of significant new scientific discoveries and the construction of a foundation of knowledge that supports future human exploration missions.

Human Exploration and Operations
FY 2013 Budget
Space Life and Physical Sciences Research and Applications Division (SLPSRA)

			NOTIONAL			
	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Total SLPSRA Budget (in $M)	231.0	240.0	[redacted]			
Exploration Appropriation	157.7	164.7	164.7	164.7	164.7	164.7
Human Research Program	157.7	164.7	164.7	164.7	164.7	164.7
Space Operations Appropriation	73.3	75.3	71.8	73.1	75.7	75.4
Biological & Physical Research	58.3	60.3	56.8	58.1	60.7	60.4
Non-Profit Organization	15.0	15.0	15.0	15.0	15.0	15.0

* Note the Multi-User System Support (MUSS) budget, including National Laboratory
Enabling, is managed by the ISS Program and therefore is not included in the above data.

Arc Jet

Question 11: We understand that NASA is planning to consolidate all Arc Jet testing capabilities at Ames Research Center (ARC) because it will require only minimal cost in upgrades to the facility and the Agency expects this consolidation effort to result in operational cost savings. What are some of the long-term efficiencies that can be gained from consolidating Arc Jet at Ames?

Answer 11: Annual operating efficiencies: consolidating NASA arc jet capabilities at Ames allows the Agency to save the ongoing annual costs of operating and maintaining the lower-power arc jet facility at Johnson Space Center with minimal impact to near- and long-term mission needs. Recent, extensive reports sponsored by both the NASA Office of the Chief Engineer and the JSC Orion MPCV program have concluded that: 1) the capabilities provided by the ARC arc jets are the minimum set necessary to meet present and anticipated Agency test requirements; 2) modifying the JSC arc jet infrastructure so that it is physically capable of matching the technical capability already operating at ARC would require hundreds of millions of dollars in new infrastructure investment—essentially, would require razing and rebuilding a new upgraded capability from scratch; and 3) actual operations costs at ARC on a per-test productivity basis are lower than JSC's and are comparable to those of other commercial and DoD arc jet facilities. In FY 2010, the NASA OCE determined the annual operations and maintenance costs of operating the JSC arc jet at $6.2M/per year. Approximately 60 percent of the annual cost of an arc jet facility is fixed costs. Over the 30-year life expectancy of a modern industrial test facility, consolidating test capability at Ames would save up to $111.6M in the fixed costs of operating the JSC arc jet facility.

Test execution efficiencies: the cost-per-test of operating at ARC is lower than at JSC. The recent study chartered by the Office of the Chief Engineer found that the FY 2010 average cost per test at JSC is $32.3K; at Ames, $16.3K. On average the JSC facility executes approximately 200 tests per year. Executing those tests at ARC would save the Agency approximately $3.2M per year.

Future capability upgrade efficiencies: Mission scenarios for planetary science missions to Mars, Venus, the gas giants, comet and asteroid sample return, and crewed missions to the Moon, Mars, and near-earth asteroids will require increased performance from arc jet infrastructure. Higher temperatures are needed to simulate the condition associated with atmospheric entry (at the destination) and reentry (to Earth) for missions of this scope. Efficiencies can be realized through concentration of infrastructure maintenance and upgrade resources on a single facility. The underlying infrastructure at Ames is designed to support very high power (up to 150 MW) arc jet operations. The corresponding infrastructure at JSC is limited to supporting low power (up to 10 MW) operations. Recent studies (ARES Corporation, Arc-Heated Test Facility Investment & Risk Reduction Study for Orion Heat Shield, May 2007) have shown that the most cost- and time-efficient approach to meeting upgraded arc jet performance requirements is to install upgraded equipment within the Ames infrastructure. This approach obviates investments in JSC infrastructure that already exist at Ames, and leverages the Agency's considerable recent infrastructure investments in the Ames facility.

Senator Mark Warner
Questions for the Record
Priorities, Plans and Progress of the Nation's Space Program
March 7, 2012

1. It is my understanding that from 2006 to 2012 funding for NASA's Aeronautics Hypersonics Project was decreased by 75 percent from $95M to $25M. The proposed FY 2013 Budget further reduces funding from $25M down to $7M- another 72 percent reduction. However, I also understand that the results of hypersonic research achieve our national security goals by increasing our global reach, responsiveness, and survivability.

   a) What was the basis for decreasing hypersonic programs to only 7 percent of the FY 2006 funding level?

   Most of the decrease in funding for the Hypersonics Project prior to FY 2012 was due to accounting changes and the elimination of one-year Congressional augmentations. The reduction from $50M in FY 2011 to $25M in FY 2012 and proposed reduction in FY 2013 reflect content changes due to required priority setting within a very tight budget environment. The Hypersonics Project had two main emphases in its portfolio: 1) fundamental research and technology development for air breathing hypersonic propulsion systems and 2) fundamental research in Entry, Descent, and Landing (EDL). With the reduction in FY 2012, the EDL-related flight experiment of inflatable re-entry system was transferred to the Office of Chief Technologist (OCT). In FY 2012, NASA prioritized funding for other, higher priority areas within the aeronautics portfolio, including research in airspace management, composites structures, and aviation safety. With the proposed reduction in FY 2013, the Agency will transfer all remaining EDL work to the Office of Chief Technologist (OCT). In FY 2013, technology development effort in air-breathing hypersonic propulsion systems such as combined cycle engines and structurally integrated thermal protection systems is planned to be phased out while retaining the Langley 8-Ft High Temperature Tunnel and research capability to support DoD's hypersonic programs. Further, NASA will effectively combine the hypersonics and supersonics research into a single project that will be focused on high-speed flight. The DoD will continue to support a larger hypersonics R&D program aimed at achieving national security goals.

   b) What results have been achieved to date through the Aeronautics Hypersonics Project?

   Recent NASA hypersonics results have largely been accomplished in partnership with the DoD. These accomplishments include validation of hypersonic vehicle design methods and ground-to-flight scaling laws resulting from X-51 wind tunnel testing in the Langley 8-Ft High Temperature Tunnel and DoD flight-testing combined with NASA-Air Force Research Lab (AFRL) Computational Fluid Dynamics (CFD) analyses. Another accomplishment is the NASA development of the scramjet engine payload to be flown as Flight 2 of the HIFiRE (Hypersonic International Flight Research and Experimentation) Program with the Air Force Research Laboratory. The Hypersonic Project also conducted the first flight test of an inflatable heat shield as well as the associated materials and computational tools to allow these new systems to be further developed. Additional technical detail can be provided upon request.

c) What is NASA's plan for achieving the same national security goals on this drastically reduced budget?

NASA Aeronautics responsibility to the national security goals related to hypersonics is to support the DoD. NASA will work with the DoD to coordinate and minimize the impact by the changes in the NASA hypersonics research on their missions. Discussions to date with DoD officials indicate that the remaining NASA hypersonics investment is aligned with their highest priorities.

2. Without the long-term research that will be eliminated under the propose FY 2013 budget, what will be the impact to NASA's Space Technology and DOD's DARPA projects and to future launch vehicles? How will this critical NASA capability for NASA and DoD be maintained beyond FY 2012?

   NASA will maintain specifically the hypersonic scramjet propulsion research and support capability associated with the NASA Langley 8-ft High Temperature Tunnel. The reason that NASA is focusing its remaining hypersonic investment around this wind tunnel is that it is key to supporting both NASA and DoD missions. Discussions to date with DoD officials indicate that the remaining NASA hypersonics investment is aligned with their highest priorities. Military applications will be the first steps toward eventually maturing the technology sufficiently to enable civilian uses such as transportation or space access. The primary impact would be to limit future opportunities to move beyond traditional rockets for such applications. At this time, NASA does not have plans or funds to build such a launch system, so there is not an immediate impact. Additionally, alternatives to conventional rockets are not just limited to hypersonic air-breathing propulsion options, and include horizontal launch options that cover the spectrum from sub-sonic to supersonic air-breathing first stage vehicles, to other more innovative and advanced concepts. However, it is anticipated that there could be an impact in supporting external research in this area and developing future engineers and scientists with skills in this area. NASA's Space Technology Program FY 2013 budget request of $699M incorporates the responsibility for the fundamental research in the area of Entry, Descent, and Landing (EDL). The actual FY 2013 appropriated funding level for Space Technology may impact all areas in Space Technology including EDL research.

3. Hypersonic air-breathing propulsion is a key component of advanced propulsion systems for launch vehicles that the National Research Council recently selected as the highest priority during their review of Space Technology Roadmaps. It takes years to develop the subject matter and expertise and the required facilities. As other countries including China, France and England more forward with robust hypersonic air-breathing projects and move into a position to capitalize on this technology as it matures for both economic and military benefits, what impact will reduced funding levels have on our national security?

The National Research Council (NRC) report called out many high priority technologies, including the 16 highest priorities. The report ranked turbine- and rocket-based combined cycle propulsion technologies the highest in the Launch Propulsion Systems technical area.

For decades, both NASA and the Air Force have invested substantial resources in these two areas. For example, the National Aerospace Plane program of the late 80's and early 90's was an effort to refine and implement these technologies. As recognized in the NRC report, both technical areas pose technical challenges that are difficult and expensive to overcome. The NRC prioritized these but added: "However, a significant number of challenges were also identified for each, and the committee believes that it will take decades of research and development and a large and sustained financial investment to makes these technologies feasible."

NASA is conducting a thorough assessment of how the Agency's current technology development efforts align with the priorities identified in the NRC report. The Office of the Chief Technologist is leading an Agency-wide gap analysis and strategic planning effort to address the recommendations made by the NRC and work with NASA Mission Directorates to determine what is possible within the Agency's current budget profile.

NASA is working with DOD to minimize the impact to their mission. For example, we are maintaining some critical national capabilities related to scramjet propulsion and the LaRC 8-ft High Temperature Tunnel to provide continued support to DOD missions.

While NASA is reducing research related to air-breathing hypersonics systems including propulsion technologies and structurally integrated thermal protection systems, the Agency decided that, in order to maintain core capabilities needed for spacecraft development, the Space Technology program will assume responsibility for the fundamental research associated with Entry Descent and Landing that had previously been conducted in the Aeronautics Research Mission Directorate. This change also creates synergies with development projects Space Technology is conducting in this technology area.

4. What has been the extent of coordination with DOD on the Aeronautics Hypersonics Project? With the proposed cuts to the NASA program, what kind of changes in the relationship and coordination with DOD do you anticipate?

NASA is actively working with the DoD to coordinate and minimize the impact of these decisions on their missions. There are some elements of research that NASA will no longer be able to support, and NASA has already met with senior DoD officials who agree that the remaining NASA investment does align with the highest hypersonic priorities in the DoD. Specifically, NASA Aeronautics is focusing its remaining hypersonic research on efforts that directly support the DoD. We are also maintaining some critical national capabilities related to scramjet propulsion to provide support for both Agency and DoD missions. NASA is aware of the DoD plans to expand research in hypersonic flight systems and is continuing to discuss options to optimize this collaboration. In the same way that NASA supported the development of the USAF X-51 system, we expect DoD collaboration and coordination to continue.

Senator Bill Nelson
Questions for the Record
Senate Committee on Commerce, Science, and Transportation
Hearing on "Priorities, Plans, and Progress of the Nation's Space Program"
March 7, 2012
Questions for the Record

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

1. **Given sustained SLS funding – what additional systems could be tested on either the 2014 or 2017 test flights, instead of waiting until the first human flight?**

ANSWER: The primary objective of the 2014 test flight is to obtain high-velocity re-entry data for the Orion MPCV spacecraft, though NASA will also use this mission to test mission operations concepts. The SLS Program is designing the spacecraft adapter for this flight. Sustained SLS funding will continue to support this effort. No additional SLS systems are applicable to this early test flight. For the 2017 test flight -- which is an Agency Priority Goal -- sustained SLS funding will provide greater confidence in meeting the necessary milestones leading up to the 2017 flight. The SLS launch vehicle for the 2017 flight is the same launch vehicle configuration that will be used for the first human flight in 2021. No additional SLS systems will be developed for the 2021 flight.

2. **Would accelerating the first human flight – earlier than 2021 – lower the overall cost of a human capable SLS-Orion system?**

ANSWER: Accelerating the first human flight would not necessarily lower the overall cost of a human-capable SLS-Orion system. NASA has implemented an executable plan to develop these systems to support the first human flight in 2021. The estimated budget to execute this plan has been phased to meet the fiscal budget requirements. If the first human flight was to be accelerated, the funds associated with accelerating the development of the necessary systems would have to be taken from the later years and re-phased into the earlier years.

We've recently heard that flights for NASA ISS commercial cargo providers have slipped – SpaceX to April and Orbital Sciences to this summer.

3. **How much have these COTS flights slipped since they were originally planned?**

ANSWER: When NASA signed the original Space Act Agreement (SAA) with Space Exploration Technologies (SpaceX) in August 2006, their first, second and third COTS demonstration flights were planned for September 2008, June 2009 and September 2009 respectively. SpaceX successfully flew the first demonstration mission in December 2010, launching a Dragon capsule into orbit on a Falcon 9 rocket and recovering it off the coast of California. On May 22, 2012, SpaceX launched its second COTS demonstration flight, and three days later, the Dragon spacecraft was berthed to the ISS. The mission, which accomplished the remaining COTS demonstration goals for SpaceX, was brought to a successful conclusion on May 31, with the deorbiting and splashdown of the Dragon capsule.

When NASA signed the original SAA with Orbital Sciences Corporation (OSC) in February 2008, the single demonstration flight was originally planned for December 2010. Currently, Orbital is planning the maiden launch of their newly named Antares launch vehicle (previously referred to as "Taurus II") no earlier than June 2012, and the COTS demonstration flight to the ISS no earlier than September 2012.

4. **What do we need to get done and when to keep research progressing on the International Space Station? At what point do further slips of SpaceX or Orbital affect operations aboard the ISS?**

ANSWER: There is sufficient margin in logistics, consumables and systems spares through 2012 so that ISS operations will not be impacted by a delay in the start of commercial cargo delivery. Commercial Resupply Services (CRS) flights will augment existing resupply capability needed to support NASA, ESA, Canadian Space Agency, and JAXA astronauts. Those needs continue to be met through the ESA-provided ATV, the Roscosmos-provided Progress and Soyuz, and JAXA-provided HTV vehicles now that the Space Shuttle has been retired. SpaceX just successfully demonstrated its ISS resupply capability and Orbital Sciences is in the process of bringing their vehicles on-line to provide the needed resupply capability. Recognizing the challenges of initial flights and bringing a new vehicle into operations, NASA and its partners previously delivered additional supplies to create a schedule margin.

The commercial strategy does not rely on a single flight or provider. To date, SpaceX has successfully flown three missions using the Falcon 9 launch vehicle, including two Commercial Orbital Transportation Services (COTS) demonstration flights. The first of these demonstrated launch, orbit and successful recovery of a simplified Dragon spacecraft. On May 22, 2012, SpaceX launched its second COTS demonstration flight, and three days later, the Dragon spacecraft was berthed to the ISS. The mission, which accomplished the remaining COTS demonstration goals for SpaceX, was brought to a successful conclusion on May 31, with the deorbiting and splashdown of the Dragon capsule.

Orbital Sciences Corporation is scheduled to fly its COTS demonstration mission in calendar year 2012, and its first CRS mission in FY 2013.

Phil McAllister, a NASA commercial crew manager, said in a recent interview that if NASA's commercial crew program gets significantly less than requested this year, the program may need complete re-thinking. As is probably clear from the 2012 appropriation, there is quite a bit of work to be done to get the appropriation for commercial crew up anywhere near the request.

5. **Can you please clarify Mr. McAllister's comments - what does it mean to completely re-think the program, and at what funding level for FY 2013 would such an action be necessary?**

ANSWER: Mr. McAlister referred to the "strategy" for the Commercial Crew Program, not the program itself. Whenever a NASA program is appropriated significantly less funding than requested, the Agency must perform an assessment to determine the impacts from the lower than anticipated budget and determine if any adjustments to the program are appropriate. NASA would have to take a similar action for Commercial Crew if the Agency receives significantly less than requested amount. Those actions are typically taken when final budgets are established.

Senator Tom Udall
Senate Committee on Commerce, Science and Transportation
Hearing on "Priorities, Plans, and Progress of the Nation's Space Program."
March 19, 2012

Questions for the Record

Question 1, for Mr. Bolden:

I know you are aware of White Sands' unique assets and capabilities. I appreciate hearing from you about NASA's goals and priorities for FY 2013.

Could you speak about some of the opportunities for White Sands to support NASA's missions? How can we take full advantage of White Sand Test Facility's capabilities in FY 2013 and beyond?

Answer: As a preeminent resource for testing and evaluating potentially hazardous materials, space flight components, and rocket propulsion systems, White Sands Test Facility (WSTF) is well positioned to support NASA mission requirements. The facility conducts simulated mission duty cycle testing to develop numerous full-scale propulsion systems. WSTF is also formally certified to perform precision cleaning and depot-level refurbishment of flight-critical propulsion systems components. Further, the scientific investigation of explosion phenomena at WSTF is aimed at improving safety at launch facilities and other areas where hazardous materials are used. WSTF is a center of technical excellence in the fields of high-pressure oxygen systems/materials and rocket propellant safety. Further, the laboratory services at WSTF are available to NASA, the Department of Defense, other Federal agencies, universities, and commercial industry.

In the area of hazardous testing, WSTF offers a set of state-of-the-art/world class lab and propulsion test facilities specializing in hazardous/non-hazardous operations and performing tests on propulsion systems, components, and materials, including: hypergolic fueled propulsion systems and components; green fuel propulsion systems and components; oxygen compatibility; hypervelocity impact in hazardous atmospheres; and standard materials testing for human space flight environment compatibility.

In addition, WSTF can perform propulsion testing of components, engines and systems at ambient (up to 60,000 lbs. thrust) and simulated altitudes of 120,000 ft (25,000 lbs. thrust) for hypergolic, liquid oxygen/liquid hydrogen, and liquid oxygen/liquid methane fuels.

Current and Future Activities:

- Continued improvements in safety, reliability, and efficiency through the execution of prioritized projects in the propulsion test facilities (Propulsion Test Area Intercom System, Altitude Simulation Vacuum System Controls, Bulk Propellant Storage)
- Specific test programs:
    - Oxygen compatibility testing for International Space Station components and materials;
    - Hypervelocity testing in support orbital debris and micro-meteoroid mitigation;
    - Space Shuttle Transition and Retirement activities to restore test stands to a neutral test state;
    - Space Shuttle post program decontamination activities;
    - Continued support to the Agency vision for space by testing hypergolic fueled propulsion components for Space Launch System and Orion Multi Purpose Crew Vehicle;
    - Support to Department of Defense and other Government organizations by safing the U.S. Air Force Peacekeeper stages, testing the U.S. Air Force Minuteman missiles, and critical Missile Defense Agency projects;
    - Support to commercial space developers and providers by testing hypergolic propulsion systems.
- Specific to NASA's commercial crew and cargo development efforts, partners may request use of NASA facilities, equipment, or services that are unique or not commercially available. Partners planning to use such NASA resources must enter into separate reimbursable agreements directly with the appropriate NASA Center(s). Any decision to use NASA facilities, equipment, or services shall be at the Participant's discretion and risk.

The WSTF propulsion test assets are managed through the Human Exploration and Operations Mission Directorate (HEOMD) Rocket Propulsion Test (RPT) Program. The RPT Program represents the single-point interface for NASA's rocket propulsion test facilities located at Stennis Space Center (SSC), Marshall Space Flight Center (MSFC), Johnson Space Center-White Sands Test Facility (JSC-WSTF), and Glenn Research Center-Plum Brook Station (GRC-PBS). The RPT sustains and improves Agency-wide rocket propulsion test core competencies (both infrastructure and critical skills), ensures appropriate levels of capability and competency are maintained, and eliminates unwarranted duplication. The program strategy is to fund and maintain core competencies of skilled test and engineering crews and test stand facilities; consolidate and streamline NASA's rocket test infrastructure; establish and maintain world-class test facilities; modernize test facility equipment; provide non-project-specific equipment and supplies; and develop effective facility/infrastructure maintenance strategies and performance.

Question 2, for Mr. Bolden:

I am pleased that NASA's budget request includes funding for the Flight Opportunities Program. This initiative provides relatively low-cost access to reduced-gravity environments that is useful for scientific research and developing new space technology. By competitively securing commercial flight services, NASA's Flight Opportunities Program leverages private investment in suborbital spacecraft and parabolic aircraft. This helps expand access to suborbital space for researchers and others seeking to conduct microgravity experiments.

Could you share some of your thoughts on the importance of this relatively small program on achieving NASA's goals in the areas of science, technology, and exploration?

Answer: The Flight Opportunities Program (authorized as the Commercial Reusable Suborbital Research Program) was proposed by NASA in FY 2010 in response to the National Academy of Sciences report: Revitalizing NASA's Suborbital Program: Advancing Science, Driving Innovation and Developing Workforce. The intent of this program is to facilitate access to near-space for a variety of users with greater frequency and affordability, and with more reliability. To accomplish these goals, this relatively small program effectively leverages private investments made by multiple companies in the emerging space sector. The program does not fund their flight vehicle development, but purchases commercial flights offered by these entrepreneurial companies.

NASA recognizes the importance of commercial reusable parabolic and suborbital flights for development of future Science and Exploration workforce capabilities. One of the greatest challenges NASA faces in advancing cutting-edge technologies is bridging the gap between testing a component or prototype in a laboratory or ground facility environment, and demonstrating the technology or capability in a mission-relevant operational environment. The cost of access to space remains prohibitively expensive with launch costs to low-Earth orbit ranging from $10,000 to $15,000 per pound for small payloads. Adding these launch costs to the cost of demonstration hardware and operations capability presents a major hurdle in the maturation of compelling space technologies. Without an ability to perform these critical relevant environment tests, not only do these new technologies remain on the shelf, but the workforce that might otherwise gain the experience to employ these new approaches remains underutilized and untrained. A key parameter for space capabilities is proving performance in a microgravity environment. It is this gap between non-microgravity ground-based testing and very expensive orbital demonstrations, where commercial reusable suborbital launch vehicles offer an enormous potential. Microgravity flights provide the potential for relevant environment testing at a small fraction of the costs required for orbital flights.

As noted in the legislative mandate for this program, and by the NRC review of NASA's Suborbital Program[1], utilizing suborbital platforms provides critical training opportunities needed to sustain a skilled aerospace workforce capable of meeting our Nation's exploration and technology development objectives. In the process of cultivating the next generation of researchers and technologists, and moving technology through the critical, flight testing phase, Flight Opportunities begins to establish a stable customer base for an emerging commercial suborbital market in the purchase of space transportation services.

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[1] "Revitalizing NASA's Suborbital Program: Advancing Science, Driving Innovation, and Developing a Workforce" \http://www.nap.edu/catalog/12862.html

Question 3, for Mr. Bolden:

I am aware that NASA is realigning some of its educational activities in accordance with the Office of Science and Technology Policy (OSTP) five-year STEM strategic plan.

Could you preview plans for any of NASA's STEM programs aimed at K-12 and university students, and speak about NASA's increased collaboration with other agencies on these efforts?

Answer: NASA is working to align its programs with the priorities identified in the five-year STEM strategic plan issued by the National Science and Technology Council (NSTC) Committee on STEM Education. NASA Education is actively engaged with federal partners through the Committee on STEM (Co-STEM), the EPSCoR Interagency Coordinating Committee, and through collaborations with the Department of Education, Department of Defense Education Activity (DoDEA), National Science Foundation, and NOAA among others.

Consistent with the status report on the NSTC Five-Year Federal STEM Education Strategic Plan released by the National Science and Technology Council, NASA will align its portfolio of activities over the next three years. In Year one, NASA will work with the Co-STEM to finalize criteria for success, develop common evidence standards, evaluation and research toolkits, and identify efficiency and productivity opportunities. In Years two and three, the Agency will establish baselines and increase alignment with the adopted criteria. NASA will align its future evaluation strategy with the Status Report on the NSTC Five-Year Federal STEM Education Strategic Plan. Successful STEM education practices and strategies identified through STEM education research studies and evaluations will also be used to guide NASA investments in STEM education. NASA will continually adjust the design of STEM education investments to align with best practices in STEM education derived from existing and new evidence from education research and evaluation.

The Aerospace Research and Career Development program strengthens the research capabilities of the Nation's colleges and universities and provides opportunities that attract and prepare increasing numbers of students for NASA-related careers. The student programs serve as a major link in the pipeline for addressing NASA's human capital strategies. The programs build, sustain, and effectively deploy the skilled, knowledgeable, diverse, and high-performing workforce needed to meet the current and emerging needs of NASA and the Nation. The research conducted contributes to the research needs of NASA's Mission Directorates and advances the Nation's scientific and technology innovation agendas.

The STEM Education and Accountability program provides competitive opportunities for NASA Centers, visitor centers, institutions of informal education, schools, universities, and non-profit organizations. These groups develop lessons, materials, research opportunities, and hands-on activities that draw on NASA's unique missions. The program includes learners from kindergarten through graduate school, educators in the classroom and in informal learning environments, college faculty, and the general public. The program emphasizes undergraduate participation in STEM research and education, preparing future scientists and engineers to enter the STEM workforce. Consistent with input received from the National Science and Technology Council Committee on STEM, NASA will provide middle school pre-service and in-service educators with NASA-themed experiences that build critical instructional STEM skills, and better enable them to motivate students in STEM. NASA activities and experiences spark interest in STEM and expose students to new career paths. Educators, both in schools, and in museums, science centers, and in community-based education organizations, will enhance their teaching practices with NASA-themed materials, experiences, and teaching strategies. NASA will engage learners of all ages through its missions, engineering challenges, and scientific discoveries.

Question 4, for Mr. Bolden:

With the retirement of the Space Shuttle, NASA currently relies on Russia to provide access to the International Space Station. The NASA budget request for the Commercial Crew program designed to replace this capability is below the FY 2012 request and the authorization level.

a. Will this funding level delay our nation's ability to service the ISS with American launch vehicles?

Answer: NASA's original request for the Commercial Crew Program was:

($ in millions)	[redacted]				
FY 2011 BUDGET	500	1,400	1,400	1,300	1,200

With this budget, NASA estimated that a commercial crew capability could be in place by 2015. However, the amount appropriated in 2011 was $312M ($188M less than requested). Thus, NASA reduced its expected progress and initiated CCDev Round 2 which only matured elements of the systems instead of overall integrated crew transportation systems. The combined impact of the lower than expected budget and having to focus on elements of the system instead of an integrated system was that it delayed NASA's expected operational date of commercial crew to 2016.

The amount appropriated in 2012 was $406M ($444M less than the newly requested amount of $850M). This resulted in a further slippage of NASA's expected operational date to 2017, given the requested funding levels in the President's FY 2013 request and reasonable technical progress on the part of the commercial providers.

NASA is planning for commercial crew capability to be in place in 2017; but, the Agency's plans will not preclude earlier availability of services. Many of the potential commercial providers have stated they could provide services earlier than 2017.

b. How much does NASA expect to ultimately pay Russia to fly astronauts to low Earth orbit before we achieve a new commercial crew capability?

Answer: In March 2011, NASA signed the most recent modification to the current International Space Station (ISS) contract with the Russian Federal Space Agency for crew transportation, rescue and related services from 2014 through June 2016. The firm-fixed price modification, valued at $753M, covers comprehensive Soyuz support, including all necessary training and preparation for launch, flight operations, landing and crew rescue of long-duration missions for 12 individual space station crew members.

Question 5, for Mr. Bolden:

New Mexico is at a high elevation and relies on snowpack water sources for irrigation and drinking water. My state is highly susceptible to variations due to weather and climate patterns and I am particularly concerned about effects of climate change. I am pleased to learn about NASA's plans for the Earth Venture program and progress developing next-generation climate and weather monitoring missions.

Could you elaborate on the goals of these missions, and the implications their findings could have for our understanding of climate change?

Answer: NASA is operating or has made significant hardware contributions to16 Earth observing satellites that are providing data on a wide variety of interactions among the oceans, atmosphere, land surface, ice sheets and biota that compose the Earth system. These data enable research that improves our scientific understanding of and enables improved prediction of climate, weather, and natural hazards. Additionally, the satellites return valuable scientific data that drive climate and weather research and provide decision support information and tools through NASA's Applied Sciences Program.

The list of currently operating satellites and their status is given in the table below. "Extended" means the mission has met all its top-level science requirements and continues to provide vital science data. "Prime" means the mission is still in its primary operating phase, collecting data on the way to meeting its top-level requirements.

Mission[1]	Launched	Phase	Scientific Issues (Goals)
Tropical Rainfall Measuring Mission (TRMM)	11/27/97	Extended	The first-time use of both active and passive microwave instruments have made TRMM the world's foremost satellite for the study of precipitation and associated storms and climate processes in the tropics.
Landsat 7	04/15/99	Extended	Landsat 7 is a joint mission of NASA and USGS to gather Earth resource data, and is the most recent in a long series of Landsat satellites going back over 35 years to 1974.
Quick Scatterometer (QuikSCAT)	6/19/99	Extended	The SeaWinds instrument on the QuikSCAT satellite is a specialized microwave radar that measures near-surface wind speed and direction under all weather and cloud conditions over Earth's

			oceans.
Terra	12/18/99	Extended	Terra simultaneously studies clouds, water vapor, aerosol particles, trace gases, terrestrial and oceanic surface properties, biological productivity of the land and oceans, the interaction among them and their effects on atmospheric radiation and climate.
Active Cavity Radiometer Irradiance Monitor (ACRIMsat)	12/20/99	Extended	The ACRIMSAT spacecraft carries an instrument which measures the Sun's total energy output, continuing a database started in 1980. ACRIMSAT data can be correlated with possible global warming data, ice cap shrinkage data, and ozone layer depletion data.
Earth Observer -1 (EO-1)	11/21/00	Extended	Earth Observing-1 (EO-1) is an advanced land-imaging mission that demonstrates new instruments and spacecraft systems. The hyperspectral instrument called Hyperion is the first of its kind to provide images of land-surface in more than 220 spectral colors.
Jason	12/7/01	Extended	Jason is an oceanography mission to monitor global ocean circulation, improve global climate predictions, and monitor events such as El Niño conditions and ocean eddies. The mission helps increase understanding of ocean circulation and seasonal changes and improve forecasting of climate events like El Niño.
Gravity Recovery and Climate Experiment (GRACE)	3/17/02	Extended	The primary goal of the GRACE mission is to accurately map variations in the Earth's gravity field over its lifetime. The science data from the mission is used to estimate global models for variable Earth gravity field approximately every 30 days.
Aqua	5/3/02	Extended	Aqua was launched with six state-of-the-art instruments to observe the Earth's oceans, atmosphere, land, ice and snow covers, and vegetation, providing high measurement accuracy, spatial detail, and

			temporal frequency.
Solar Radiation and Climate Experiment (SORCE)	1/25/03	Extended	SORCE provides state-of-the-art measurements of incoming x-ray, ultraviolet, visible, near-infrared, and total solar radiation. The measurements specifically address long-term climate change, natural variability and enhanced climate prediction, and atmospheric ozone and UV-B radiation.
Aura	7/15/04	Extended	Aura's objective is to study the chemistry and dynamics of the Earth's atmosphere with emphasis on the upper troposphere and lower stratosphere (0-30km) by employing multiple instruments on a single satellite. Each instrument makes daily global observations of Earth's atmospheric ozone layer, air quality, and key climate parameters.
Cloudsat	4/28/06	Extended	CloudSat is designed to fly in formation with CALIPSO to provide a comprehensive characterization of the structure and composition of clouds and their effects on climate under all weather conditions.
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)	4/28/06	Extended	CALIPSO flies three instruments in formation with Aqua to obtain coincident observations of radiative fluxes and atmospheric conditions. This enables new observationally based assessments of the radiative effects of aerosol and clouds that is greatly improving our ability to predict future climate change.
Ocean Surface Topography Mission (OSTM)/Jason 2	6/20/08	Extended	OSTM/Jason 2 measures sea surface height by using a radar altimeter mounted on a low-Earth orbiting satellite. Measurements of sea-surface height, or ocean surface topography, reveal the speed and direction of ocean currents and tell scientists how much of the sun's energy is stored by the ocean.

Aquarius	6/10/11	Prime	By measuring sea surface salinity over the globe with such unprecedented precision, Aquarius will answer long-standing questions about how our oceans respond to climate change and the water cycle. Monthly sea surface salinity maps will give clues about changes in freshwater input and output to the ocean associated with precipitation, evaporation, ice melting, and river runoff.
Suomi-NPP	10/28/11	Prime	NPP is the bridge between the EOS satellites and the forthcoming series of Joint Polar Satellite System (JPSS) satellites. NPP data will be used for both climate research and operational weather prediction.

1. Information on the measurements these missions make and the research and applications that they enable is available at: http://nasascience.nasa.gov/earth-science/missions/

The following missions are in development or formulation:

Mission	Planned Launch Readiness Date
Landsat Data Continuity Mission (LDCM)	2013
Global Precipitation Measurement (GPM)	2014
Orbiting Carbon Observatory-2 (OCO-2)	2014
Stratospheric Aerosol and Gas Experiment (SAGE III on ISS)	2014
Soil Moisture Active/Passive (SMAP)	2014
ICESat-2	2016
Gravity Recovery and Climate Experiment-Follow-on (GRACE-FO)	2017

Several other missions are in a pre-formulation study phase.

Venture-Class

Venture-Class is a Tier-I Decadal Survey recommendation and is a program of regular competitive solicitations designed to enable science-driven, PI-led, cost- and schedule-constrained, innovative orbital and suborbital missions from academia and private industry as well as from NASA Centers. The Venture-class investigations complement the systematic missions identified in the Decadal Survey, and provide flexibility to accommodate scientific advances and new implementation approaches.

Venture-Class is fully funded, with 3 "strands"

- EV-1: suborbital/airborne investigations (5 years duration)
  - Solicited in FY 2009 (selections in FY 2010) *and every 4 years*
  - 5 investigations selected; flights began in FY 2011
- EV-2: small complete missions (5 years duration)
  - Solicited in FY11 (selections in FY 2012) *and every 4 years*
  - Small-sat or stand-alone payload for MoO; $150M total development cost
  - AO released 17 June, proposals received 29 Sept 2011, under review
- EV-Instrument: Spaceborne instruments for flight on MoO (5 years dev.)
  - Solicited in FY 2011 (selections in CY12) *and every 15-18 months thereafter*
  - Final AO release Feb 7; proposals due May 8, ~$90M development costs, accommodation costs budgeted separately

NASA's Research and Analysis programs and the Applied Sciences Programs, generate the research understanding and the efficient data products that users need to redeem the nation's investment in the flight missions.

The Earth Science R&A activity is built around the creation of new scientific knowledge about the Earth system. The analysis and interpretation of data from NASA's satellites form the heart of the R&A program in the Earth Science Research Program, although a full range of underlying scientific activity needed to establish a rigorous base for the satellite data and their use in computational models, including those for assimilation and forecasting, is also included. The complexity of the Earth system, in which spatial and temporal variability exists on a range of scales, requires that an organized scientific approach be developed for addressing the complex, interdisciplinary problems that exist, taking good care that in doing so there is a recognition of the objective to integrate science across the programmatic elements towards a comprehensive understanding of the Earth system.

Through the Applied Sciences Program, NASA develops and demonstrates practicable applications of its research satellite observations and model results for use by decision makers. NASA works directly with decision makers throughout the development of applications.

Two recent examples of NASA Earth Science Research and Applications follow.

NASA's GRACE Data enhances North American Drought Monitors

Many regions in the United States experienced record-breaking drought in 2011. To better understand drought so that decision makers can accurately manage the best uses of a limited water supply, an Applied Sciences-funded project in the Water Resources Program is using GRACE (Gravity Recovery and Climate Experiment) data to enhance the U.S. and North American Drought Monitors, the premier decision support tools for drought monitoring purposes.

To address the need for better drought information and enhanced decision support tools, an Applied Sciences-funded project led by Matt Rodell, hydrologist at NASA's Goddard Space Flight Center, is working with NOAA, the National Drought Mitigation Center at the University of Nebraska Lincoln, and a team from the University of California Irvine to develop new drought indicator maps using Earth observations from GRACE and other missions.

GRACE – paired satellites that travel approximately 137 miles apart and detect small variations in the Earth's gravitational field – data is useful because it provides valuable information on water stored both on top of and below the land surface. This includes snow, soil moisture and groundwater. Having a complete picture of all these water types gives a much more accurate picture of drought.

Prior to the addition of GRACE data and other satellite observation into the drought monitors, the maps lacked information on soil moisture and groundwater storage – two areas that GRACE has been able to enhance greatly.

But GRACE's spatial and temporal resolutions are low. Because of this, GRACE data alone would not provide the complete picture necessary for sound water management decision-making. Rodell's team uses the GRACE data and combines it with a long-term meteorological data-set – including precipitation and temperature, satellite based solar radiation data, and high resolution land surface modeling to produce a continuous record of soil moisture and groundwater that goes back to 1948. The soil moisture and groundwater record is used to produce weekly maps of wetness conditions in the soil and aquifers.

To view the weekly maps, visit http://www.drought.unl.edu/MonitoringTools/NASAGRACEDataAssimilation.aspx.

NASA's efforts to assess snowpack for improved snow-water run-off forecasts

NASA is addressing the challenge of assessing seasonal water supply estimates from snow melt on three fronts. Improved land surface models from better observations, improved scientific knowledge, and advanced computing capabilities, sensor and model improvement from airborne observatories and campaigns, and better space observations leading to persistent measurements of snow cover and snow depth.

NASA Water Resources Program is supporting numerous projects building on a NASA modeling and modeling framework capabilities. These capabilities have expanded the use of scientific models to wide audiences of researchers and decision-makers. One example is with NOAA/National Weather Service (NWS) National Operational Hydrologic Remote Sensing Center (NOHRSC) to develop North American information for Alaska. This project is now expanding the effort to assess the impact on the NWS Alaska-Pacific River Forecast Center's region.

Airborne and spaceborne observations of snow-based reservoirs have greatly increased in quality and quantity of the past few years. NASA has been improving upon initial MODIS (on Terra and Aqua) algorithms to detect snow cover and have an improved product that allows better monitoring during the critical snowmelt phase of some snowpacks. NASA has also been exploring the use of hyperspectral remote sensing information, current available using NASA aircraft instruments, as well as in discussion for a future satellite recommended by the decadal survey (HyspIRI), to better understand the effects of (blown) dust on snow melt rates. As an example, various observations were combined in 2010 that allowed NASA scientists to warn particular water districts in Colorado that blown dust would significant enhance melt rates allowing them to better manage the (eventual) water capture system of this precious resource.

Questions for William Gerstenmaier
From Chairman Ralph Hall
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. **Since one of NASA's COTS providers- Orbital Sciences Corporation (OSC)- uses modified Russian hardware on its launch vehicles, when will NASA need to seek a waiver to the Iran, North Korea, Syria Non-proliferation Act (INKSNA) to buy their launch services?**

ANSWER: We are already on contract with OSC for cargo support to the International Space Station (ISS) through the current exception period. (ending June 30, 2016). Some modification of the Iran, North Korea, Syria Nonproliferation Act (INKSNA) provisions will likely be required to continue using those services after 2016.

2. **Other than the Soyuz purchases what other aspects of the International Space Station partnership will require an INKSNA waiver?**

ANSWER: Modification may be needed for Russia-unique ISS goods and services including, among other things, Russian space suits and extravehicular activity tools, sustaining hardware support for the Functional Cargo Block (FGB) and docking adapters.

It should also be noted that some entities that have expressed an interest in pursuing commercial opportunities are contemplating teaming plans that could include Russian goods or services. In order to justify the expense of final development, long lead procurements, production, and flight testing, industry needs certainty as soon as possible as to the status of the present INKSNA human space flight prohibition as they make future business and teaming plans that could include Russian goods or services for future procurements.

3. **When does the Administration plan to begin to work with Congress on the necessary INKSNA provisions?**

ANSWER: As Dr. Holdren said to Congressman Palazzo during his June 20, 2012, hearing before this committee, "I agree with the importance of getting a modification to the Iran, North Korea and Syria Nonproliferation Act for the purpose you indicate. And it's clear that it's going to be required. It's clear that sooner is better than later." NASA looks forward to working with Congress on an appropriate INKSNA modification.

4. **One of the goals in establishing a National Laboratory was to broaden the range of research that could be done on the ISS to include more applied research, technology development and industrial processing. Given that the Center for the Advancement of Science in Space (CASIS) organization is managed under the same NASA division that provides grants for other basic research, how will NASA ensure that it can accomplish this wider range of**

applied research objectives?

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

5. **Given NASA inability to enforce requirements on COTS participants through Space Act Agreements, and given that NASA has spent over $835M on CRS milestone payments without successful COTS demonstrations, what recourse does NASA have if the initial COTS test flights are not fully successful?**

   ANSWER: The COTS and Commercial Resupply Services (CRS) efforts are separate activities. The Commercial Orbital Transportation Services (COTS) effort is a demonstration program based on milestone payments. If a vendor does not meet a milestone, NASA will not pay for that milestone. It should be noted that on May 22, 2012, SpaceX launched its second COTS demonstration flight, and three days later, the Dragon spacecraft was berthed to the ISS. The mission, which accomplished the remaining COTS demonstration goals for Space X, was brought to a successful conclusion on May 31, with the deorbiting and splashdown of the Dragon capsule.

   The payments NASA has made on the CRS contracts are for long-lead items and milestone payments, which are typical for launch vehicle contracts. Launch vehicle contracts typically provide for payments incrementally prior to launch.

   a. **If any of the COTS demonstrations are unsuccessful, with NASA re-compete the commercial cargo program?**

   ANSWER: Regarding COTS, if a partner misses a milestone, then NASA assesses whether the partner has in place a reasonable plan for successfully completing the milestone in the future. No payments are made until successful completion. Given the progress made by both partners to date, including the completion of COTS flight demonstration milestones by SpaceX, NASA does not plan to recompete the COTS agreements if the remaining demonstration is unsuccessful.

6. **Much of our discussion has focused on the capacity to get supplies and equipment to the ISS, but the ability to bring scientific payloads back to Earth is currently limited to 132 pounds on the Soyuz. Is this sufficient to meet the needs of the research community?**

   ANSWER: On the return trip to Earth from the recent COTS demonstration mission, the SpaceX Dragon capsule carried science experiments that will be returned to researchers hoping to gain new insights provided by the unique microgravity environment in the station's laboratories. In addition to the experiments, Dragon returned a total of 1,367 pounds of hardware and cargo no longer needed aboard the Station. NASA anticipates that SpaceX Dragon spacecraft will continue to provide the downmass required to meet the needs of the research community through the terms of the current contract. Follow-on CRS contracts will also include downmass services to meet the needs of the U.S. Operating Segment (USOS). The USOS is currently staging return research on ISS until Dragon is available to return the cargo.

a. **How much mass is the Dragon capsule expected to bring back and will this provide enough down-mass to serve the intended community?**

ANSWER: The Dragon capsule is expected to return approximately 1,400 kilograms (3086 lbs) of downmass. At a projected 3 flights per year, the expected return capability is sufficient to meet all ISS projected return requirements.

b. **Please provide the anticipated downmass requirements for the 2012-2020 timeframe.**

ANSWER: The anticipated recoverable downmass requirement for ISS is an average of 2,200 kilograms (4850 lbs) per year for the years 2012-2020.

7. **The GAO report from last year suggests a shortfall of launch capacity to meet the requirements of the ISS. If launch capacity is diminished for any reason, or contingency maintenance increases, where do the offsets come from?**

ANSWER: ISS utilization is a high priority for NASA and its partners. However, if launch capacity is diminished or contingency maintenance increases, NASA and its partners would have to reduce upmass dedicated to research in order to ensure continued Station operations.

a. **How does NASA prioritize the supply and maintenance needs with the research needs?**

ANSWER: NASA and its International Partners would coordinate to ensure that critical maintenance and operations needs are met. Each Partner would determine its own research priorities based on its share of the remaining upmass, and CASIS would determine the priorities of National Laboratory research based on its own allocation.

8. **What steps is NASA taking to reduce the sparing and utilization demand of the ISS between now and 2020?**

ANSWER: Thanks to Space Shuttle missions STS-134 and -135, the ISS has been well provisioned in terms of spares and supplies, and as the CRS providers' vehicles become available, ISS sparing and utilization demands will be met. At the same time, NASA and its partners are working to reduce these demands by conserving resources on orbit. One example is the increased use of the Station's Control Moment Gyros to change the attitude of the vehicle, reducing the consumption of propellant by the ISS.

9. How is NASA's expertise being shared and used by the National Lab researchers?

ANSWER: Several technical interchange meetings have been held between CASIS management and NASA field center personnel to provide CASIS with information on NASA capabilities that may be of use to National Lab researchers. CASIS is also identifying "implementation partners," organizations offering services in research payload design and development to National Lab researchers. These organizations have typically acquired their expertise through experience as NASA contractors and participation in the NASA SBIR program.

a. Please provide some examples of the ways NASA is working to make experiments more autonomous to require less up mass and downmass.

ANSWER: A number of experiments on ISS are already autonomous or ground-controlled (the Alpha Magnetic Spectrometer is an example of the former). NASA is working on ways to downlink highly detailed information about research results to ground-based scientists to minimize the need to return actual experimental samples to Earth, thus reducing downmass requirements. Laboratory analysis techniques are being developed that can be used to perform tests on biological specimens on the ISS and thus reduce the number of samples that have to be returned to Earth for analysis. The Agency is also taking advantage of smaller, lighter experiments in order to decrease upmass requirements and increase the amount of research that can be done on ISS.

10. What is the current state of negotiations with the European Space Agency for future ATV missions beyond the three remaining, and does NASA assume any ATV s will be available beyond 2014?

ANSWER: NASA does not require Automated Transfer Vehicles (ATVs) beyond #5, which will be flown in 2014, and is in early discussions with ESA to provide an alternative barter acceptable to NASA and ESA.

a. What is the current state of negotiations with the Japanese Space Agency for future HTV (H-II Transfer Vehicle) missions beyond the five remaining, and does NASA assume any HTVs capabilities will be available beyond 2016?

ANSWER: NASA is planning to discuss its needs for future HTV missions with the Japan Aerospace Exploration Agency (JAXA) as part of its barter arrangement negotiations.

b. **What amount of domestic commercial capacity does NASA assume with be available in each year from 2012 thru 2016?**

ANSWER: NASA anticipates 1-2 commercial cargo flights in FY 2012, and 4-5 per year from FY 2013 through FY 2016, with delivery of a minimum of 20 metric tons of cargo to the ISS, as well as the return or disposal of 3 metric tons of cargo, during that time period. The Agency will have to negotiate for commercial cargo resupply after FY 2016.

11. **According to GAO's testimony, in 2011 NASA anticipated 56 flights to the ISS between 2012 and 2020 and would likely be at risk of a shortfall to cover all of the national laboratory demands and margin for unforeseen maintenance. However, in March NASA told GAO that in spite of decreasing the anticipated flights to 51, NASA is no longer projecting a cargo shortfall. What changes have occurred to cause NASA to reduce the number of flights without having any impact on estimated cargo needs?**

ANSWER: The main factors influencing NASA's cargo requirements projection are: 1) equipment on board ISS is lasting longer than originally anticipated; and 2) the Agency's conservation efforts have enabled a reduction in the projected fuel requirements for ISS.

12. **How is NASA coordinating with the new National Lab management entity, and are there management issues or NASA funding constraints that could limit or restrict the ability to fully utilize the ISS National Lab?**

ANSWER: NASA coordinates with CASIS, the ISS National Laboratory management organization, through the ISS Program Office and the Human Exploration and Operations Mission Directorate. CASIS coordinates its flight planning, payload development, and research operations with the ISS Program Office, and its strategic guidance, management policies, and program planning with HEOMD. NASA is not aware of any management issues or funding constraints that could limit or restrict the ability to fully utilize the ISS National Lab.

13. **Who pays for the launch costs for experiments that are flown by the academic institutions and other non-NASA researchers?**

ANSWER: NASA will pay for the launch costs of experiments flown by academic institutions and other non-NASA researchers involved in the ISS National Laboratory.

a. **If CASIS is successful in increasing the research demand on the ISS, what impact if any would that have on NASA's budget?**

ANSWER: NASA's budget already assumes that the Agency will pay for launch and on-orbit utilities costs for the users of the ISS research capacity allocated to the National Laboratory, as managed by CASIS. NASA will take into account the demand for access to ISS in determining future budgets for research.

14. **GAO's written testimony noted that NASA has developed a method and statistical process to determine the expected lifetimes of replacement parts. Are ISS critical spare parts already in inventory so they could be available on short notice (assuming there is rocket to carry them), or are there critical spares that do not exist yet that will be funded in future budgets? If so, what are those?**

    ANSWER: NASA has spare Orbital Replacement Units (ORU's) either on-orbit, in inventory on the ground, or in the procurement process for all systems to meet safe operations to 2020 based on the current models for life expectancy, except for one. NASA is in the process of evaluating the cause of the ammonia pump failure that occurred in August 2010. If the cause of the failure is determined to be systematic, the 3 replacement ORU's currently on-orbit are likely to be insufficient to meet safe operations to 2020. If the cause is determined to be a unique event, the current ORU's on-orbit would be sufficient. If the cause is systematic, NASA would evaluate if it would be cost-effective to build and manifest the same design, or if it would be more cost-effective to design and build a new configuration. In either case NASA is evaluating whether or not the current pump package or a new configuration could be accommodated on currently available cargo vehicles.

15. **To what extent do NASA's research requirements impact or constrain the operations and management of the ISS National Laboratory?**

    ANSWER: At present, there are no resource conflicts between NASA research resource requirements and ISS National Laboratory utilization.

    a. **How will NASA allocate the capacity on cargo flights to prioritize between NASA's own research needs and those of the ISS National Lab?**

    ANSWER: NASA develops and integrates the cargo manifest across the partnership and across the multiple partner cargo vehicles including Progress, ATV and HTV. NASA is also beginning to develop and integrate the manifest for the upcoming SpaceX and Orbital CRS missions. NASA takes into consideration actual on-orbit needs and performance as well as increment science priorities as established by the COUP (Consolidated Operations and Utilization Plan). These needs and requirements are then balanced against the flight readiness and capabilities of the individual flight vehicles. NASA works across the partnership and science stakeholders, including National Lab users, to ensure that their needs and priorities are being met.

16. **NASA's testimony reveals that the agency no longer assumes the availability of the European Automated Transfer Vehicle (ATV) after 2014. Since the A TV has been used to carry propellants how does NASA plan to do without**

this capability?

ANSWER: NASA does not require the capabilities of the ATV after 2014, and the remaining ATVs to be flown to ISS will supply the Station's propellant needs. After that, the ISS partnership will use Russian Progress cargo vehicles to deliver propellant to the ISS and to conduct ISS reboosts.

a. **The European contribution to ISS amounts to 8.3 percent, so if ESA doesn't provide ATV after 2014 what type of contribution will ESA make?**

ANSWER: NASA is in early discussion with ESA to provide an alternative barter acceptable to NASA and ESA.

17. **Since crew availability as a significant constraint to the productivity of the ISS National Laboratory, how does NASA plan to address this constraint, and how significant will it be going forward?**

ANSWER: Even with six crewmembers aboard ISS, crew availability is a constraint on research. NASA and its partners are working to decrease the amount of crew time required to conduct experiments by using crewtime more efficiently, by increasing the autonomy of the experiments, and by enabling ground-based scientists to conduct their research through improved downlinks and uplinks with ISS. The ISS Program Manger has made using crew time for research the highest priority, and now requires justifications for operations and maintenance activities that would impact crew time for research. To the maximum extent practical, "housekeeping" systems involving redundant tasks are being automated to reduce crew time requirements and free up additional crew time for research. Finally, the ISS Program is examining options for evolving to a seven-person crew in the future so the additional crew time can be made available to support research.

18. **Are there critical spares or other components that are too big and heavy for the capabilities being contemplated by the CRS (Commercial Resupply Service) providers?**

a. **If so, please list them, and describe the contingency plans NASA has to ensure the overall health of the ISS thru 2020?**

ANSWER: With the exception of a replacement radiator and batteries, all other critical spares that might be required by ISS can be launched with the CRS vehicles, and the heavy batteries that might be required for Station can be launched externally on Japanese HTVs. Even in the case of the radiator, NASA is reviewing the prospects for breaking the radiator into component pieces that can be launched on separate vehicles.

b. **If necessary, could the ATV (Automated Transfer Vehicle) or HTV (H-**

11 Transfer Vehicle) or Progress vehicles carry the largest and heaviest components?

ANSWER: Please see response above.

19. Do the Russians have the industrial capacity to produce additional launch systems after 2016 to satisfy crew transportation demand if commercial crew systems or the Space Launch System (SLS) and Orion are not ready?

ANSWER: The Russians have the industrial capacity to produce additional launch systems after 2016 to satisfy crew transportation demand if U.S. systems are not ready, though NASA would have to provide notice well in advance of the intended launch timeframe in order to ensure the availability of the Soyuz spacecraft.

20. When would NASA and the international partners need to decide on extending the life of the ISS?

ANSWER: The decision to extend ISS Operations beyond 2020 will need to be made well before 2020 to enable a smooth continuation of the program.

a. Please describe the actions that would be necessary in the next few years to enable NASA to extend the ISS beyond 2020.

ANSWER: NASA is currently looking at the technical feasibility of extending the life of the ISS beyond 2020; this effort is aided as the commercial partners continue to gain on-orbit experience with the Station's structure and systems. In addition to certifying ISS' systems to operate beyond 2020, the decision to extend the life of the vehicle would require multilateral agreement among the Station partners. If the ISS is extended, NASA would prefer to have procurements in place by the end of FY 2017.

Questions for William Gerstenmaier
From Ranking Member Eddie Bernice Johnson
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. **Given the limited resources we have available, we need to better understand our national objectives in using the ISS.**
   a. **What are NASA's three highest priority objectives for utilizing the ISS before 2020 and what is the status of your progress on meeting those objectives?**

ANSWER: NASA's highest priorities for utilizing the ISS are (1) meeting international commitments so that all International Partners succeed in advancing research that benefits humanity, (2) NASA's exploration mission driven research in biophysical sciences and spacecraft technology, and (3) applied research in the U.S. national interest that demonstrates the practical benefits of orbital space stations.

The recent "International Space Station Benefits for Humanity" publication (http://www.nasa.gov/mission_pages/station/research/benefits/index.html) highlights the partnership's progress in using the ISS to improve life on Earth in the areas of human health, Earth observation and global education. NASA's exploration driven research encompasses both the human research program, which is steadily addressing the risks associated with future human exploration (see question 3), and the technology development program, which is utilizing the ISS to demonstrate enhanced communications, environmental control and life support, power and propulsion, advanced materials and visiting vehicle technologies. Finally, the ISS as a National Laboratory provides space-based opportunities for advancing the nation's basic and applied science and technology interests to other U.S. government agencies, university-based researchers and private firms.

   b. **How is NASA managing ISS constraints and resources to meet those objectives?**

ANSWER: NASA integrates the utilization requirements across the ISS partnership and works with science stakeholders, including National Lab users, to ensure that their needs and priorities are being met within the available resources. Even with six crewmembers aboard ISS, crew availability is a constraint on research. NASA and its partners are working to decrease the amount of crew time required to conduct experiments by using crewtime more efficiently, by increasing the autonomy of the experiments, and by enabling ground-based scientists to conduct their research through improved downlinks and uplinks with ISS. Biomedical research on human health and performance in space uses the majority of the available crew time, not only because it is the highest priority research on the ISS, but also because in biomedical research, the crew is both the investigator and the subject. Recent agreements with our ISS partners to share access to crewmembers, as subjects for biomedical research, and data from biomedical investigations will enable increased efficiency in the use of on orbit crewtime.

In addition, the ISS Program Manger has made using crew time for research the highest priority, and now requires justifications for operations and maintenance activities that would impact crew time for research. To the maximum extent practical, "housekeeping" systems involving redundant tasks are being automated to reduce crew time requirements and free up additional crew time for research. Finally, the ISS Program is examining options for evolving to a seven-person crew in the future so the additional crew time can be made available to support research.

c. **Is there an overarching strategy that maps the experiments to human exploration mission requirements or priority scientific objectives?**

ANSWER: The Human Research Program has developed an overarching space human health risk architecture that focuses its research on the highest risks associated with future human exploration missions. Crew health and performance is critical to successful human exploration beyond low Earth orbit. The Human Research Program (HRP) investigates and mitigates the highest risks to human health and performance, providing essential countermeasures and technologies for human space exploration. Risks include physiological effects from radiation, hypogravity, and terrestrial environments, as well as unique challenges in medical support, human factors, and behavioral health support. The HRP utilizes an Integrated Research Plan (IRP) to identify the approach and research activities planned to address these risks, which are assigned to specific Elements within the program. The Human Research Roadmap is the web-based tool for communicating the IRP content (http://humanresearchroadmap.nasa.gov/).

2. **What the government pays for commercial crew and any additional cargo services in the latter part of the decade will also have a bearing on funds available for research, assuming total ISS costs continue at about the same funding level. What funding level is NASA assuming in the FY 2013 budget plan for commercial crew and cargo costs in FY 2016 and beyond?**

ANSWER: In the President's FY 2013 Budget Request, the ISS Crew and Cargo Transportation is notionally budgeted in the ISS Program, under the Space Operations account, at \$1.8B in FY 2016 and \$1.9B in FY 2017 (the final year of the 5-year budget runout). In addition, the Commercial Crew Program, under the Exploration account, is notionally budgeted at \$829.7M per year from FY 2013 through FY 2017.

What analysis are the commercial crew and cargo costs beyond FY 2016 based upon, given none of the commercial systems have yet flown?

ANSWER: In order to reduce program risk, NASA has budgeted for commercial crew seats using the current Soyuz contract as a basis of estimate. There continues to be a lot of uncertainty regarding the ultimate commercial crew seat cost since this program is in the early stages of development and there are a wide variety of potential providers with different approaches. This approach to budgeting for commercial crew seats protects NASA should commercial crew be delayed and provides flexibility to address the uncertainty in costs. The current Commercial Resupply Services (CRS) contract was used as a basis of estimate for cargo transportation in FY 2016 and beyond.

3. **In 2007, NASA prepared a Human Research Plan for the ISS that identified key risks and the anticipated timeframe required from the ISS to address the risk and validate countermeasures.**
    a. **What is the status of retiring the risks identified in that 2007 plan? Have you updated it?**

ANSWER: NASA has implemented the ISS flight studies identified in the 2007 plan and made significant progress understanding and mitigating the health risks associated human space flight. Significantly, NASA has made progress in the following areas: 1) understanding how to manage space-induced bone and muscle loss by using new exercise protocols and pharmaceutical and nutritional countermeasures; 2) behavioral and performance risks associated with sleep disruptions and monitoring of crewmember alertness; 3) demonstrating exploration medical capability including in-flight IV fluids production; 4) management of crewmember orthostatic intolerance; 5) added new ISS biomedical capabilities including the second-generation ultrasound for medical imaging, the urine monitoring system, the jointly developed ESA/NASA muscle atrophy research and exercise system, and Portable Pulmonary Function System; and 6) identified a significant health risk visual impairment/intracranial press (VIIP) that has been already incorporated into future ISS flight plans.

Since the 2007 Human Research Plan, HRP has completed and started the following ISS flight experiments:

<u>Completed</u>

- ISS Urine Monitoring System (UMS)
- ISS Ultrasound 2 to provide high-resolution biomedical images
- Evaluation of Commercial Compression Garments to Prevent Post-Spaceflight
- Orthostatic Intolerance
- Sleep-Wake Actigraphy and Light Exposure During Spaceflight
- Behavioral Issues Associated with Long Duration Space Expeditions: Review and Analysis of Astronaut Journals
- Spinal Elongation and Its Effects on Seated Height in a Microgravity

Environment

- Surface, Water, and Air Biocharacterization- A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft Environment
- Cardiovascular and Cerebrovascular Control on Return from ISS (NASA managed and implementation in agreement with CSA)
- Intravenous Fluid Generation for Exploration Missions

<u>Started and On-going</u>

- Cardiac Atrophy and Diastolic Dysfunction During and After Long Duration
- Spaceflight: Functional Consequences for Orthostatic Intolerance, Exercise
- Capacity, and Risk of Cardiac Arrhythmias
- Maximal Oxygen Uptake During Long Duration International Space Station Missions
- Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss
- Validation of Procedures for Monitoring Crewmember Immune Function
- Nutritional Status Assessment
- Physiological Factors Contributing to Changes in Post-Flight Functional Performance
- An Integrated Resistance and Aerobic Training Study for the Validation of an
- Exercise Countermeasures Regimens Aboard the International Space Station
- Biomechanical Analysis of Treadmill Exercise on the International Space Station
- Dietary Intake Can Predict and Protect Against Changes in Bone Metabolism During Spaceflight and Recovery

Currently, HRP is conducting 14-16 studies per increment with an additional 5-6 experiments in definition phase being prepared for flight. Results are made available as soon as practical, given the investigator's right to publish. Results are published in technical journals, NASA technical publications, and the HRP Evidence Books. In FY 2011, NASA flew 11 major medical experiments to optimize exercise, nutrition and sleep to evaluate the immune system and other human health areas to make exploration missions healthier, safer, and more productive. NASA completed two of these ISS research studies and initiated three new studies.

NASA is continually updating both its strategic and tactical ISS flight plans to optimize ISS experiment throughput and maximize crew participation in biomedical flight experiments. The HRP strategic flight plans associated with each risk area are contained in the Integrated Research Plan (IRP). The IRP is available via the Human Research Roadmap (<u>http://humanresearchroadmap.nasa.gov/</u>) and is updated on a yearly basis.

The tactical ISS flight plans list the current and planned human research experiments that will be undertaken in each ISS increment and is updated continually throughout the year. The tactical ISS flight plans, or ISS Fly-Off plan, is available at the ISS Medical Project website (http://www.nasa.gov/exploration/humanresearch/elements/research_info_element-issmp.html).

b. **Do you have similar plans and timelines for technology development and scientific research? If not, why not?**

ANSWER: NASA's HRP maintains a comprehensive research plan, called the Integrated Research Plan (IRP), which includes both flight and ground experiments and facilities. The IRP is available via the Human Research Roadmap (http://humanresearchroadmap.nasa.gov/). The Integrated Research Plan lays out for the scientific community the expected progression of research and technology tasks intended to address critical questions that must be answered to quantify the risks or develop mitigation strategies for the risks as they relates to the overall exploration mission campaign plans. The HRP research and technology activities are performed on ISS either because there are no effective ground-based analog environments to conduct the work on Earth, or the research activity needs the complete operational environment of space flight to validate the countermeasure or technology. The ISS is necessary to mitigate 22 of the 31 human health risks in the HRP portfolio.

4. **I understand that NASA is encouraging prospective researchers using the Station to develop experiments that can be performed autonomously and do not require crew intervention and participation. Since these researchers are likely to be more knowledgeable in their own field than on automated support technology, what is NASA doing to assist in transferring its knowledge of automated support mechanisms to the research community?**

ANSWER: Extensive automation of flight experiments does require more complex designs and more expensive experiment systems. To date, NASA has accommodated ISS investigators primarily in NASA-built experiment systems. As the ISS National Laboratory concept matures, the capabilities of the payload development contractors who plan to support on-orbit research will need to evolve to build more complex experiments. NASA and the ISS National Laboratory management organization, the Center for the Advancement of Science in Space, are holding information exchange meetings to identify resources and establish interfaces that will enable National Laboratory participants to access the expertise available at NASA field centers.

5. **GAO reported last December that NASA had not attempted to develop techniques or equipment to conduct x-ray or sonographic inspection of the ISS because doing so would be expensive, impractical, or both. Can you elaborate on the size of those costs and what makes them**

impractical?

ANSWER: During NASA's investigation into methods for evaluating the ISS structural components, it became clear that methods such as x-ray or sonographic inspection would entail removal of ISS ORU's and other equipment from the base structure in order to accommodate inspection devices. This was deemed impractical and cost prohibitive, as the ISS was not designed to be stripped of its equipment on-orbit and inspected by such means. As a result, NASA has employed thorough analytical methods to assess structural life.

Questions for William Gerstenmaier
From Congressman Dana Rohrabacher
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. **Given that grants to U.S. universities are the primary mechanism for funding peer-reviewed biological and physical science research, why out of $3B operations budget for FY 2012 is only $9.6M being used for grants and principal investigator support?**

   ANSWER: The total FY 2013 budget request for ISS is $3.0B, full cost. Less than half of the FY 2013 ISS budget, $1,493.5M, is for ISS Systems Operations and Maintenance. The ISS Crew and Cargo Transportation budget is $1,284.8M. The remaining budget of $229.3M is for ISS Research and includes three major categories: Multi-User System Support (MUSS), the Non-Profit Organization (NPO), and biological and physical research.

   The MUSS budget, $154.0M, provides strategic, tactical, and operational support to all the NASA sponsored payloads and non-NASA sponsored payloads, including international partner research payloads. This budget incorporates maintenance and operation of the ISS research infrastructure, including research integration, payload engineering, payload integration, payload operations payload systems support etc. The $15M NPO budget supports the Center for the Advancement of Science in Space (CASIS) and will likely also fund some grant activity. The biological and physical research budget, $60.3M, is comprised of grants, principal investigator funding and grant support such as hardware development, civil servant and contractor labor, and other activities required of the grantees in order to conduct their research on ISS. Of the $60.3M for biological and physical research, approximately $15M is being applied to grants and principal investigator support in FY 2013.

   There are several other budgets outside of ISS which also contribute to research and technology demonstrations on ISS. For example, NASA's Human Research Program is providing approximately $30M in ISS research support. The Office of Chief Technologist (OCT), Advanced Exploration Systems (AES), and Space Communications and Navigation (SCaN) are also funding technology activities which will ultimately be demonstrated on ISS. It should also be noted that the experience of maintaining and operating a system such as ISS is, in and of itself, providing valuable research for future exploration missions.

2. **In NASA's FY 2013 ISS budget, how much is allocated for biological and physical research university grants, and how does that compare with FY 2012?**

   ANSWER: The biological and physical research budget in FY 2012 is $58.3M (excluding MUSS and NPO), and approximately $12M will be awarded directly for grants. The planned biological and physical research budget for FY 2013 is $60.3M, of which ~$15M will be awarded in grants.

3. **What is the rationale for managing Biological and Physical Research as part of the ISS operations budget?**

   ANSWER: The near term strategic goal of ISS Research is to conduct a program of scientific research endorsed by the research community and focused on the accomplishment of outstanding scientific objectives. ISS biological and physical research is dependent on ISS operations for success. The Space Life and Physical Sciences, Research and Applications (SLPSRA) Division has management of biological and physical research and the ISS program has the responsibility for operating the vehicle and managing ISS utilization for NASA and its partners. Retaining the ISS biological and physical research budget within the overall ISS budget is reflective of this symbiotic relationship and supports collaboration between the two offices.

Questions for William Gerstenmaier
From Congressman Randy Neugebauer
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. **If current projections and timelines for commercial crew and Orion do not pan out, will we still be relying on Russian Soyuz after 2016? Do we have a guarantee that the Soyuz will be operational at that time?**

   ANSWER: If U.S. commercial vehicles and Orion MPCV are unavailable beyond 2016, then NASA would continue to purchase Soyuz seats for crew transportation and rescue purposes, as the agency has been doing for several years, assuming appropriate INKSNA modification and pending sufficient contracting lead time. NASA anticipates that Soyuz vehicles will still be operational at that time; they continue to be the Russians' only crew-carrying spacecraft.

   a. **What consideration has NASA taken in the potential for a change in agreements with the Russians based on geopolitical tension or frayed international relations?**

   ANSWER: The Russians have proven to be very reliable partners in the ISS Program; their efforts to provide additional Soyuz transportation in the aftermath of the 2003 Columbia Shuttle accident enabled the partnership to continue operating the Station. However, the continuing reliance of the U.S. on an international partner for crew transportation and rescue services underscores the importance of developing domestic commercial crew services as soon as possible.

2. **What are your projections, assessments, and predictions for the future of the ISS past its current timeframe of 2020?**

   ANSWER: NASA is currently looking at the technical feasibility of extending the life of the ISS beyond 2020 – possibly to 2028. This effort is aided as the partners continue to gain on-orbit experience with the Station's structure and systems. In addition to certifying ISS' systems to operate beyond 2020, the decision to extend the life of the vehicle would require multilateral agreement among the Station partners.

Questions for William Gerstenmaier
From Congressman Brad Miller
March 28, 2012 Hearing on
Securing the Promise of the ISS-Challenges and Opportunities

1. In February, the executive director of CASIS (Dr. Jeanne L. Becker) resigned from her position citing serious concerns regarding the relationship of ProOrbis, a for profit consulting firm, with CASIS. She cited pressure from some NASA officials, an unnamed congressional staffer and Space Florida board members for CASIS to pursue engagements with ProOrbis. This was despite a legal opinion from CASIS's attorneys stating that CASIS's continued involvement with ProOrbis could jeopardize CASIS's non-profit status. These are very serious allegations.

a. **What NASA has done to look into these allegations?**

ANSWER: NASA's Office of the Inspector General is reviewing this matter.

b. **Has NASA contacted the NASA IG about this?**

ANSWER: NASA is aware that the NASA IG is reviewing aspects of the CASIS cooperative agreement and is providing all requested information to the IG.

c. **CASIS was hired by NASA to manage the U.S. National Laboratory on the ISS. Can you provide us with any insight into why NASA or other interested parties would interfere with CASIS's ability to carry out its duties to manage the ISS Laboratory or attempt to interfere with the organization's ability to carry out its mission?**

ANSWER: NASA fully supports CASIS' management of the National Laboratory aspects of the ISS and looks forward to transitioning the existing National Lab Memoranda of Understanding and Space Act Agreements over to CASIS.

d. **What is NASA's legal opinion as to whether having Pro Orbis involved with CASIS is a conflict-of-interest?**

ANSWER: Based on the known facts, NASA is not aware of any organizational conflicts of interest. Civil servants prepared the Cooperative Agreement Notice. Although ProOrbis prepared the reference model, this information was publicly available and proposers could elect to adopt portions of the reference model and/or include ProOrbis as a team member in their proposal.

e. **Is there anything else you can add about how NASA is handling this situation, ensuring that these allegations are investigated thoroughly and helping CASIS gets back on track quickly?**

ANSWER: NASA is working to ensure that CASIS continues to move forward to fulfill its responsibilities to stimulate, develop, and manage the national use of the ISS, and is fully cooperating with the review by the NASA IG. NASA is assessing the progress made by CASIS in standing up their organization and establishing an initial research portfolio, and will be working with CASIS management to correct any shortcomings that may be identified.

f. **How do you believe these recent events may impact the management of the scientific projects anticipated for the International Space Station?**

ANSWER: At present, no long-term impact to the management of the ISS National Laboratory is anticipated. Planned work like the review of biological and biomedical research opportunities has been completed on schedule, and other planned activities, such as the 2012 research solicitation, are on schedule. Working with a nationally known executive search firm, the interim CASIS Board of Directors has identified candidates for the new Board, and the new Executive Director. The new Board is expected to be in place this summer, and will be responsible for selecting the new Executive Director.

QUESTIONS SUBMITTED BY SENATOR HUTCHISON

Sequestration

At each of our hearings this year each department has been asked about the impact of the budget sequestration might be. As NASA's budget already has a cut as part of the FY 2013 budget request, and several programs are being reduced to the bare minimum needed to maintain schedule, the impact of sequestration could cause mission schedules to slip and when that happens, increased costs inevitably follow.

Question. What will the overall impact be to the agency?

Answer. NASA has not initiated planning for sequestration and fully expects that the Congress and the Administration will enact balanced deficit reduction legislation and thereby avoid the need for a sequestration. If necessary, the Administration will be addressing important technical questions concerning a sequestration and NASA cannot speculate at this time the size or effect of sequestration.

Question. If sequestration requires reductions to programs at NASA, what will NASA's rationale be for applying funding reductions to its programs? Will NASA reduce every program, project and activity by the percentage, and if not, justify the agency's decision to spare some programs over others from the effects of a funding reduction?

Answer. NASA has not initiated planning for sequestration and cannot speculate at this time the size or effect of sequestration.

Orion as backup

The NASA authorization specifically identifies SLS and Orion to be used as a backup to commercial crew. This was done in case the primary providers are unable to fulfill the need for ISS support. You have previously stated that Commercial Crew is plan A for reaching the ISS, and it is also plan B because NASA would like to subsidize more than one company for their development and then pay them again to ride to the space station. At the same time, if they cannot deliver, NASA will have to scramble to determine a rocket configuration for Orion to do the job, or continue paying the Russians for seats.

Question. Does NASA have a plan, if the need arises, to exercise the Orion backup capability?

Answer. The Orion Multi-Purpose Crew Vehicle (MPCV) will have the capability to provide an alternate means of delivery of crew and cargo to the International Space Station (ISS). Although funds are not currently being spent to enable this capability, this capability will not be precluded. This would be a highly inefficient use of the SLS and MPCV designs, so NASA would only develop the capability "...in the event other vehicles... are unable to perform that function" per the NASA Authorization Act of 2010 (P.L. 111-267).

Question. If a plan exists, or even if one does not, please provide an estimate for the cost and timeline that would be needed for Orion to take crews to the ISS in case of commercial crew being unable to deliver crews to the ISS as defined in section 302(c)(1)(D) of PL-111-267.

Answer. The Space Launch System (SLS) and Orion MPCV are expected to execute the system's first launch in 2017 and be crew capable in 2021. The SLS is a heavy lift launch vehicle and has payload capability far and above that which is necessary to support ISS crew rotation and resupply activities; therefore, launching an SLS for ISS-related activities would be a highly inefficient use of the system that is simply not cost-effective. However, in an emergency, the SLS could be used for Low Earth Orbit (LEO) operations. In addition, the Orion MPCV is a crew vehicle that is primarily designed for deep space exploration and, if needed for an emergency, could function as a backup vehicle for the International Space Station (ISS) crew. The current Orion design is specifically designed and tailored for deep space exploration and a high-speed reentry to Earth, which includes systems that are not necessary for LEO missions. Launching the Orion MPCV capsule for use in LEO would also be an inefficient use of a robust system intended for other purposes.

NASA has assessed the content changes needed to perform ISS missions as a backup, including required technical changes and the associated cost and schedule. The additional Orion MPCV costs for the ISS mission would be at minimum $300M. Additional cost would be incurred if schedule is critical.

Shuttle retirement payment

As part of the close out of the Shuttle program, NASA has a onetime payment to the contractor for their employee retirement plan. This payment was agreed to by NASA when the United Space Alliance was created to service the orbiters for NASA. Last year the Committee was assured that the amount funded in last year's appropriations bill was the amount necessary to make this payment. However, since that time the amount has changed and the payment will likely be higher than NASA anticipated when funds were appropriated for this payment.

Question. Can you tell us what the current payment is anticipated to be and which programs NASA intends to look to in order to make up the difference if necessary?

Answer. Our latest estimate is that termination of the United Space Alliance employee retirement plans will cost between $535M to $555M. This estimate could change once the formal termination is approved; however, we do not anticipate that it will greatly change. The difference between what was appropriated, $470M, and the final cost will be covered within the Space Shuttle Retirement and Transition line of the Space Operation account.

Santa Susana Field Laboratory

I understand that NASA is involved in the cleanup of a former rocket engine test facility in Ventura County, California – called the Santa Susana Field Laboratory (SSFL). In December 2010, NASA and DOE signed administrative orders on consent (AOC(s)) with the State of California that obligated the federal parties to cleanup portions of the site.

Question. What level of cleanup did NASA commit to in the AOC, and is that cleanup level required by federal or state law?

Answer. The Administrative Order on Consent (AOC) calls for a cleanup to "background." Per AOC Section 2.1, "[t]hat is, at the completion of the cleanup, no contaminants shall remain in the soil above local background levels, with [certain specific exemptions]."

Federal law required cleanup of sites contaminated any hazardous materials. NASA entered into the AOC as part of an out of court settlement with the Department of Toxic Substance Control (DTSC). Under the terms of the AOC, compliance with the AOC "shall constitute NASA's full and complete compliance with all applicable provisions of Chapters 6.5 and 6.8 of Division 20 of the California Health and Safety Code (the California Hazardous Waste Control Law, Sections 25100 *et seq.* of that Code, and the California Hazardous Substances Account Act, Sections 25300 *et seq.* of that Code), including specifically, but not limited to, California Senate Bill 990 (Stats. 2007, c. 729), which has been codified as Section 25359.20 of the California Health and Safety Code, but only with respect to the application of these provisions to radiologic or chemical contamination of soil at the Site or any contiguous radiologic or chemical contamination of soil emanating from within Area II and the portion of Area I owned by NASA, within or without the SSFL boundaries, identified by DTSC as part of the investigation of chemical contaminants."

The AOC also requires NASA in Section 4.2.3 that "NASA shall conduct all activities under this Order in a way that will promptly comply with the requirements of NEPA."

Question. How does this level of cleanup compare to cleanup levels at other sites that NASA is involved in?

Answer: The final cleanup levels (what is meant by background for the proposed action) have not been specifically established by the State. In order to conduct the required NEPA evaluation of the proposed AOC cleanup and reasonable alternatives, NASA has developed estimates based on the background levels determined in 2005 along with the latest laboratory reporting limits used by the State. The chart below summarizes the proposed AOC cleanup and three other standard land use scenarios under other cleanup programs.

	Proposed Action (AOC Cleanup)	**Alternative 1 (Residential)**	**Alternative 2 (Industrial)**	**Alternative 3 (Recreational)**
Removal Volume (cy)	502,000	182,000	92,000	58,000
Estimated Cost	$210M	$80M	$40M	$25M
Truckloads Required	26,421	9,579	4,842	3,052
Duration	100	36	18	12

(months) assuming 12 trucks per day

Question. If the cleanup is not required by law, and it differs from cleanups at other sites, why is NASA making this commitment?

Answer. NASA entered into the AOC as part of an out of court settlement with DTSC. Cleanup of contaminated sites with hazardous materials is required under federal law, specifically the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation Liability Act ("CERCLA"). NASA's cleanup actions are completed under these authorities or under State authorized RCRA or CERCLA programs.

Question. Under the AOC how many cubic yards of soil will need to be removed?

Answer. The final cleanup levels have not been specifically established by the State. However, based on engineering estimates to meet levels required by Section 2.1 of the AOC limits and assuming excavation and offsite disposal, the current estimate would be approximately 502,000 cubic yards. This estimate is based on background levels determined in 2005 and current laboratory reporting limits.

Question. What is NASA's cost estimate for complying with the AOC? How much more will the Santa Susana AOC cleanup cost compared to what it costs NASA to do the cleanup it does at other sites?

Answer. The final cleanup levels (what is meant by background for the proposed action) have not been specifically established by the State. In order to conduct the required NEPA evaluation of the proposed AOC cleanup and reasonable alternatives, NASA has developed estimates based on the background levels determined in 2005 along with the latest laboratory reporting limits used by the State. The chart below summarizes the proposed AOC cleanup and three other standard land use scenarios under other cleanup programs.

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Truckloads Required	26,421	9,579	4,842	3,052

Duration (months) assuming 12 trucks per day	100	36	18	12

Question. Does cleanup under the AOC need to comply with the National Environment Policy Act (NEPA)?

Answer. NEPA is a statutory requirement (*42 U.S.C. 4321 et seq.*) and, as such, is reflected as a requirement of the AOC. Under the terms of the AOC: "*4.2.3. NASA shall conduct all activities under this Order in a way that will promptly comply with the requirements of NEPA*".

Question. Will compliance with NEPA require consideration of all land use and cleanup alternatives?

Answer. Section 4.2.3 of the AOC requires that "NASA shall conduct all activities under this Order in a way that will promptly comply with the requirements of NEPA." NASA is obligated to evaluate all reasonable alternatives or a range of reasonable alternatives in enough detail so that the public can compare and contrast the environmental effects of the various alternatives. NASA is currently conducting an environmental review of the impacts of the AOC and will consider land use and cleanup alternatives consistent with NEPA's statutory and regulatory obligations.

PROCEDURES TO FOLLOW IN PREPARING AND EDITING HEARING TRANSCRIPTS AND SUBMITTED QUESTIONS FOR THE RECORD

Because of time constraints placed on the Senate Appropriations Committee in processing hearings, the Committee requests you to observe the following instructions when preparing hearing transcripts.

GENERAL

One copy of the transcript (the original will be sent to you as soon as possible after each hearing. This original copy is to be returned to the Committee Editorial and Printing Office (Room SD–126) by the due date posted on the transcript (usually 3 weeks). The returned transcript should include all inserts and responses to any questions asked during the hearing which required further explanation.

PLEASE E-MAIL ALL WITNESSES' STATEMENTS AND ANY INSERTS TO:

Reginald_Stewart@appro.senate.gov

OR TO

Print-ed@appro.senate.gov

INCLUDE IN THE E-MAIL THE AGENCY SUBMITTING THE DATA AND THE DATE OF THE HEARING.

If there should be an insert or explanation which requires a longer time to prepare than the due date given on the transcript, indicate what insert or question is missing when returning the transcript. This privilege should not be abused. It is extremely important that the transcript be returned to the Committee by the date specified.

Responses to questions for the record submitted to the agency at the close of the hearing should be returned to the Committee (with one photocopied set) within 3 weeks of receipt.

All statements, inserted material, and record questions and answers should be e-mailed. Any questions may be answered by calling the Editorial and Printing Office (224–7265).

It will be the responsibility of the Budget Liaison Officers to make certain that Committee instructions on transcripts and submitted questions are followed by offices contributing material to transcripts or answers submitted to questions. Material not submitted in proper format will be returned for correct form.

THE TRANSCRIPT

Transcripts can be returned from the Department either by hard copy, fax, or PDF file e-mailed of the corrected pages.

Short headings should be inserted at a minimum of one heading every three pages of transcript copy. A new heading should be added after each insert.

If a subcommittee member requests information to be provided for the hearing record during the hearing, the information should be inserted at the proper place following the request. One additional copy should be furnished to the subcommittee staff.

All inserts should be original copy, whenever possible, free from punched holes, contain no staples, and if two sided, two copies must be furnished.

Inserts should be inserted following the appropriate pages in the hearing record. The transcript page number where the material should be inserted, together with an identifying letter, encircled in pencil, should be arrowed in between the lines of the transcript, as

"Insert 23A follows". The insert should then be inserted behind the page referred to with the notation "23A" in the top right corner.

Be certain to spell out acronyms the first time used.

Spell out "million" instead of using M to indicate amount. Show dollar figures as decimal to one place as follows: "$7.8 million"; or full numerical figure when rounding to one decimal is not appropriate: "$7,845,000". "Thousands" should be written in full figures (e.g. $25,000, not "$25 thousand").

Any charts used in oral testimony should be numbered (1, 2, etc.) and should be placed in appropriate place of the transcript.

A Senator's remarks should be corrected only for typographical errors. If there is a misstatement of fact or some other reasons which you believe justifies making a change, do not make the change, but attach a note with the suggested change on the page where you believe the change should be made.

Any photographs or graphs to be reproduced in hearing record must be clear and legible. If a PowerPoint file or other data file is available please e-mail to the Editorial and Printing Office.

SUBMITTED RECORD QUESTIONS

Submitted questions will be given to the appropriate budget officer after each hearing. Record questions must be returned to the Committee 3 weeks after date of receipt.

An original and one copy of submitted questions and answers should be provided to the Committee. The copy is for transmittal to the Senator submitting questions.

In order to obtain conformity in style in typing submitted questions and answers, please observe the following:

Answers to written questions submitted by the presiding Senator or subcommittee staff shall carry the heading centered:

"QUESTIONS SUBMITTED BY SENATOR _________"

Each question submitted should be retyped in full prior to respondent's answer. Questions should be prefaced by the word "Question.", and the answer prefaced by the word "Answer." (each followed by a period)

Center headings should be typed in all capitals in space provided with only one blank line above and below heading

Each question and answer should be typed single-spaced. You may answer more than one question on a page. Double space between the answer and the next question. Indent each paragraph five spaces.

Do not number questions.

Avoid personal or individual references. It is the Department or Agency responding, not individuals.

In a series of submitted questions relating to the same subject matter, answer each question separately. In other words, do not type all the questions and then all the answers. There may be a few exceptions where one or two questions may best be combined in a single answer. Check with the Committee staff to determine whether this is appropriate.

Any charts, tables, etc. in an answer should follow as soon thereafter as possible any written explanation. In other words, do not identify a table as Table A, and then insert the table after an entire series of questions and answers. Insert the pertinent chart or table following reference to it.

Indicate in charts and tables whether figures are in thousands, millions, etc. All tables should have totals. (For example, a listing and description of R&D contracts should include a total at the end.)

If similar questions are submitted which require identical answers, refer the questions and answers to the attention of the Committee staff, so they may determine whether it is appropriate to modify or delete one of the questions.

PROOFS

Proofs must be returned to the Committee by date requested.

Check proofs of all material submitted to see that they have been inserted in the appropriate places in the proofs.

All corrections on proofs should be made with colored pen or pencil, preferably red, in the main. Make corrections easy to find and read.

Make note of, and supply, any missing inserts as indicated by the printer.

Corrected pages can be faxed or e-mail a PDF file.

ATTACHMENT: Sample sheet for preparation of record questions

INSTRUCTIONS FOR PREPARING QUESTIONS AND ANSWERS

More than one question and answer may appear on a page. In fact, it is preferable to fill the page. Group questions and answers by Senator.

Any questions, please call 224–7265, 7266, 7217, or 7267

SAMPLE AS TYPED BY AGENCY

QUESTIONS SUBMITTED BY SENATOR HATFIELD

PROGRAM PARTICIPATION

Question. In all the Child Nutrition Programs, there is an anticipated increase in the number of free and reduced price meals served. To what do you attribute this increase?

Answer. The anticipated increase in the number of free, reduced price and paid meals served is based on increased school enrollments and higher.

STATE ADMINISTRATIVE EXPENSES

Question. Within the Child Nutrition account, there is a line item called "State Administrative Expenses," (SEA), which provides matching funds to the States for administering Child Nutrition Programs.

Answer. There has been continuing concern with the fact that almost one-half the amount allocated for State administrative expenses remains unused. SAE funds which remain unobligated by a State on September 30, 1986.

OFFICE	FY 1993	FY 1994	FY 1995
Policy & Direction	$26,600	$25,500	$25,500
Aviation Safety	11,000	11,000	11,000
Surface Transportation	5,500	8,000	8,000
Research & Engineering	5,500	8,000	8,000
Administration	5,500	5,500	5,500
TOTAL	54,100	58,000	58,000

DO NOT TYPE QUESTIONS AND ANSWERS AS FOLLOWS

Question: In all the Child Nutrition Programs, there is an anticipated increase in the number of free and reduced price meals served. To what do you attribute this increase?

Answer. The anticipated increase in the number of free, reduced price and paid meals served is based on increased school enrollments and higher.

Questions for Dr. Jaiwon Shin
From Subcommittee Chairman Steven M. Palazzo
April 26, 2012
An Overview of the NASA Aeronautics Research Mission Directorate's Budget for Fiscal Year 2013

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1. The NRC report, *Recapturing NASA's Aeronautics Flight Research Capabilities*, states that NASA Aeronautics has not done a good job disseminating research results. What is your response to this assertion?

   In order to transition research results into use by government and private sector stakeholders, NASA Aeronautics does currently disseminate its research results, concepts, and design methods as widely as possible through a variety of mechanisms. NASA Aeronautics has disseminated the results of its research by publishing our results in peer-reviewed journals and NASA Technical Reports. Furthermore, we have established technical working groups within projects to engage industry and academic partners on a regular basis in order to facilitate knowledge transfer. Space Act Agreements are also used to establish intellectual partnerships with industry that enable NASA to leverage industry's unique systems-level expertise while enabling industry to quickly acquire research results and establish close working relationships with the researchers both internal and external to NASA who contribute to the research. One example of a successful NASA Aeronautics' mechanism is the DASHlink virtual laboratory the aviation safety research community uses to share results and collaborate on research problems in health management technologies for aeronautics systems. (https://c3.nasa.gov/dashlink/) Research Transition Teams (RTTs) established between NASA and the FAA are another key mechanism for transition of our results, cited by GAO as a best practice for government collaboration. RTTs improve progress for NextGen advancements in critical areas and efficiently transition advanced capabilities to the FAA for certification and implementation. Under RTTs, NASA and FAA develop joint research plans and fund their respective portions of the planned research according to the nature of the research and their relative capabilities.

   In addition, NASA Aeronautics disseminates information about the purposes, progress and ultimate benefits of its research to public audiences through Web feature stories, images and videos published at *nasa.gov* and at *aeronautics.nasa.gov*. NASA Aeronautics also introduces the public, including other researchers, students and educators, to specific areas of research and the people conducting that research through live Web chats, educational materials, and hands-on activities at major outreach events.

2. What percentage of ARMD's budget pays for personnel, for infrastructure, and for overhead; and what portion does ARMD put out in the form of research grants? In your opinion, are the personnel and infrastructure expenses appropriate for the size of your program?

   Approximately 35% of the FY 2012 ARMD budget is allocated for civil servant labor, and about 20% of the budget is for contractor labor. Costs for general center infrastructure and

overhead are paid out of the Cross Agency Support appropriation and are not a part of the ARMD budget.
ARMD does fund the Aeronautics Test Program (ATP) with an annual budget of approximately $75M. ATP ensures the strategic availability, accessibility, and capability of a critical suite of aeronautics ground test facilities and flight operations assets to meet Agency and national aeronautics testing needs. These assets are utilized by all NASA Mission Directorates and external customers.
ARMD does not award grants, but through our NASA Research Announcement (NRA) process we award approximately $75M a year of contracts and cooperative agreements to academia and industry. These agreements allow us to work collaboratively with our research partners to ensure the most effective technology development and transfer for the aeronautics community. In our opinion, the personnel and infrastructure expenses are appropriate for our current budget level and research portfolio.

3. What is NASA's response to the NRC's recommendation to consolidate flight research activities at Dryden Flight Research Center?

   NASA has a very broad range of flight research objectives and believes that flight research tests should be conducted using the aircraft and test locations that are best suited to meeting the objective of each research project. The Dryden Flight Research Center aircraft, facilities, and resources are particularly well-suited to some current research projects such as the development of low-boom supersonic commercial aircraft and unmanned aerial vehicles (UAV). Such projects rely on the restricted access of the Western Aeronautical Test Range that is maintained by Dryden to enable their flight tests. Other flight research needs to be performed in environments far from Dryden. For example, we are currently equipping a research aircraft to measure ice crystal properties in the vicinity of tropical convective storms near Darwin, Australia. Such storms occur primarily in the tropics and cause engine power loss events which are not well understood and which pose a hazard to trans-oceanic commercial aircraft operations. We are also interested in the effects of alternative aviation fuels on the formation of contrails, which require flight tests in northern latitudes that are conducive to contrail formation. Flight tests aimed at improving performance of air vehicles ranging from helicopters to hypersonic aircraft are often accomplished by leveraging the assets of our partners such as the Army, the Air Force, the FAA, and commercial entities using platforms and test sites, which are determined by our partners. NASA will continue to invest in and utilize the resources of the Dryden Flight Research Center when they are the most appropriate to achieving our mission to enhance aircraft safety and performance across all speed regimes.

4. Looking to the future, how will NASA and industry be able to afford building a flight research vehicle that would be of an appropriate scale to demonstrate and validate new designs and technologies, if the cost ranges into the hundreds of millions of dollars? Does NASA foresee the day that such a large flight demonstration vehicle would be necessary?

   An important aspect of bringing a new aircraft technology to maturity is the safe and successful integration of that technology into an aircraft system. In other words, the performance benefits of a new concept demonstrated in a ground test facility or wind tunnel must be proven to be achievable in flight, to be safe, and to be certifiable by the FAA. There are two approaches to demonstrating such systems integration. The first approach is the design, construction, and flight test of a purpose-built full-scale or sub-scale flight demonstration vehicle that can simultaneously incorporate several new aerodynamic, structural, and propulsion technologies. Recent studies of such an approach for subsonic commercial aircraft conducted by the NASA Environmentally Responsible Aviation Project show that the cost would indeed be several hundred million dollars. The second approach is to demonstrate a particular new concept by flight testing that concept using an existing aircraft. Such an approach is currently being utilized by the FAA Continuous Lower Energy, Emissions, and Noise (CLEEN) program which is accelerating the maturity of new environmentally-friendly aircraft technologies in order accelerate their certification and entry into the fleet. A similar approach was utilized in 2005 by the Quiet Technology Demonstrator Two (QTD2) program conducted by Boeing, General Electric Aircraft Engines, Goodrich Corporation, NASA, and All Nippon Airways. The QTD2 flight tests enabled the incorporation of several new technologies on Boeing's latest 787 and 747-8 aircraft. Given the current budgetary realities it is not likely that a purpose-built flight demonstration vehicle can be funded, even through multi-participant partnership, in the near future. For the immediate term, the second approach of modifying existing aircraft to demonstrate new concepts is the most realistic. In the longer term new concepts such as low-boom supersonic aircraft, which will rely on the unique shape of the entire aircraft configuration to achieve acceptable sonic boom levels, will require a purpose-built flight demonstration vehicle.

Questions for Dr. Jaiwon Shin
From Ranking Member Jerry Costello
April 26, 2012 Hearing on
An Overview of the NASA Aeronautics Research Mission Directorate's Budget for Fiscal Year 2013

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1. What are the key steps in how ARMD selects the highest priority aeronautics research initiatives? How is stakeholder input weighed and incorporated in this prioritization process? When did NASA start using the current prioritization scheme? Are any changes to the prioritization scheme envisioned in the near future?

   Aeronautics uses a combination of systems analysis, inputs from research stakeholders, and judgment of our subject matter experts to formulate priorities for research initiatives. First, the input of our subject matter experts is critical to projecting the timeframe and potential for advancement to the state-of-the-art across the aeronautical disciplines. With that understanding, systems analysis can provide insight into the relative merits of those advancements in a total systems context. Systems analyses can also help determine top-down "goal posts" for technology advancements in order to achieve key system metrics derived from strategic assessment of aviation needs.

   While expert judgment and analysis provides key insights into our investment trade-offs, we also look to understand the priorities of research stakeholders, such as manufacturers and operators. They bring substantial real world insight into aeronautical challenges, at the system-of-systems, system and technology levels. Their inputs are received through participation in our systems analyses, through dialogue at technical interchange meetings, at the Aeronautics Research and Technology Roundtable and other executive level discussions.

   Overall, this is a continual process of assessing the portfolio content and enabling decision-making as a part of the budget process. This current process has been developing over the last several years and we don't envision major changes to it at this time. However, we will continue to improve our analysis process and dialogue with our stakeholders.

2. How is NASA determining if the Aeronautics Research and Technology Roundtable is an effective way for stakeholders to provide input to NASA? When does NASA expect to provide Congress with its first report on the roundtable?

   Through two full meetings of the Aeronautics Research and Technology Roundtable, we have engaged in valuable dialogue with stakeholders and believe that it is one effective way for NASA to garner input. We have already received a very good perspective on future cross-cutting needs for the aeronautics community as was discussed in the bi-annual report provided to Congress on May 16, 2012.

3. One of the goals of the Environmentally Responsible Aviation project is to enable, twenty years from now, a simultaneous reduction of fuel burn, noise, and emissions. With current technology, reducing fuel burn might increase some emissions. What breakthroughs in technology are needed to accomplish those simultaneous reductions?

The ERA project is focused on technology maturation in five key areas that will enable achieving the goal of simultaneous reduction of fuel burn, noise, and emissions. The first area is drag reduction, which will contribute to fuel burn reduction. Required technology development includes advanced wing technologies, such as high aspect ratio swept wings, and active control of flow that would reduce drag and weight. The second area is weight reduction, which also contributes to fuel burn improvements and will be enabled by continued advances in composites technology. We are developing an efficient approach to building lightweight, damage arresting, unitized structures that will reduce weight and part count and enable more efficient airframe configurations through high aspect ratio wings and alternate architectures. The third key area is propulsion technology. Both propulsor and core engine efficiency gains are needed to simultaneously reduce engine fuel burn and noise. The development of high thermal efficiency compression systems and lower speed fans is key to the realization of next generation ultra high bypass (UHB) turbofan engines. The fourth key area, emissions reduction, will be enabled by new lean-burn combustor design architectures that improve the management of fuel and air mixing to reduce the formation of nitrogen oxides (NOx) within the combustor. The final key technology area combines the efficient integration of the propulsion system and airframe with airframe noise improvements. Successful engine-airframe integration will simultaneously improve propulsion system performance and reduce community noise. Airframe noise reduction will be enabled by streamlining landing gear and developing new concepts for high lift systems such as flaps and slats needed during landing and takeoff.

Comprehensive systems analyses indicate that advancements in each of the five key areas described contribute to the achievement of the aggressive ERA project goals. In addition, it appears that the efficacy of the integrated benefits of these technologies is dependent on the configuration. That is, analyses indicate that these advanced technologies when integrated on some unique configurations potentially offer more benefits that those same technologies integrated on an advanced conventional, tube-and-wing configuration.

The ERA project is currently identifying the most promising technologies from these areas to down select for further research and integration in phase 2 of the project.

4. What factors go into establishing the proper balance between fundamental research and flight research? Have advances in ground testing reduced the amount of flight-testing that must be conducted?

Flight research is performed at all levels of technical maturity – from very early concept and technology exploration through large-scale demonstrations in relevant environments. Therefore, it is not a question of fundamental research versus flight research, but of where is flight research the best tool for the type of research to be performed – whether that is fundamental research or integrated, systems-level research. The types of factors that need to be considered are whether flight provides access to conditions that cannot easily be replicated in other experimental environments, the level of uncertainty in physics-based simulations for the key areas of technical interest, and the level of fidelity that is required to answer the research question.

Advances in numerical simulation, ground test and flight test have changed the relationship between the three. High fidelity numerical simulation allows ground test and flight test to be more targeted and therefore require less overall test time. At the same time, sensor and measurement technology advancements have enabled more detailed information to be gathered in ground and flight test that enables more precise validation of numerical methods. In some cases, flight test becomes more important than ground test since the often complex, integrated and non-linear conditions that can be achieved in flight are the conditions least suited to high confidence numerical simulation.

5. One of the significant changes in your FY 2013 budget request is the proposed restructuring of the hypersonics work and the elimination of research in air breathing hypersonic propulsion systems.

    - What NASA capabilities and expertise will be lost as a result of the restructuring the hypersonics work? Has NASA been engaging in discussions with DOD to determine the fate of this research? What has DOD told you?

      NASA partners with the DOD in many aspects of hypersonics research, and NASA expertise and facilities have been instrumental in DOD hypersonics efforts such as the X-51. NASA plans to maintain the LaRC 8-ft High Temperature Tunnel and some of the related research capability to support such work. Prior to the reduction, NASA was a joint sponsor with the DOD in air breathing hypersonic research, but this responsibility falls primarily to the DOD moving forward.

      NASA is engaging with the DOD at multiple levels to minimize impacts. The NASA-USAF Executive Research Council and the National Partnership for Aeronautical Testing are forums for the two organizations to meet at a senior level to address such issues. ARMD program and project leaders have also held meetings with DOD counterparts to discuss how to continue as much research as possible. These meetings will continue throughout the summer to further develop the partnerships and plans.

      The DOD has expressed a concern because they did not anticipate having to allocate their funds for acquiring NASA expertise to support their air breathing hypersonics programs. However, they support NASA's decision to focus remaining hypersonic funding on the LaRC 8-ft High Temperature Tunnel and related research.

    - Why were Entry, Landing and Descent activities transferred out of the aeronautics budget and what will that transfer mean for aeronautics capabilities?

      Responsibility for fundamental research associated with Entry, Descent, and Landing (EDL) technologies will be transitioned to Space Technology in FY 2013. This research is critical for developing future systems that the Agency may employ to land payloads either on Earth or other planets, and the change aligns the EDL research more closely with related space flight in the Space Technology portfolio. NASA's EDL capabilities will be retained, but funded through Space Technology instead of ARMD.

6. An increasing number of aircraft manufacturers are moving towards composite materials because of weight savings.

- Does NASA have any composite materials research that addresses progressive damage analysis, aging, inspection and repair techniques?

- What type of research could help us better understand how operating fluids and mechanical loads interact with composite materials over time? Is this type of research currently being performed? If not, why not?

Background:
The understanding of the material properties of metals and the ability to predict the load-carrying capability of metallic structures is highly advanced within the aeronautics community and is an enabler for the performance of modern aircraft. Composites are rapidly making their way into aircraft because of their superior strength-to-weight advantage over metals and their resistance to fatigue and corrosion. However, current composite structures are conservatively designed because we don't have a first-principles capability to model composite material properties and to analyze the load-carrying capability and fatigue resistance of composite structures. To take full advantage of composites and accelerate their future use in aircraft requires improved composite materials modeling, structural analysis, and manufacturing technology. Further details provided below.

Does NASA have any composite materials research that addresses progressive damage analysis, aging, inspection and repair techniques?
Efforts in the Aviation Safety Program have included demonstration of self-healing composite materials, which can restore compressive strength of a composite material that has been subjected to impact. Complementary efforts include computational modeling to simulate discrete composite matrix cracks. Research is also looking for methods of preparing surfaces for adhesive bonds and non-destructive methods for measuring integrity of bonds. The significance of efforts such as these is that future composite materials designers can predict the conditions under which the cracks may form, develop designs to avoid these conditions, and provide knowledge for effective repairs.

Composites research in the Fundamental Aeronautics Program is primarily focused on models to enable the design of new composite materials and structural components for future air vehicles. Improved computer models of composite materials behavior offer great potential to simulate failure modes accurately and to predict the residual strength of composite structures. We are also conducting limited efforts on in-situ non-destructive evaluation (NDE) for progressive damage analysis to reveal when there is growing delamination inside composite structures.

The Integrated Systems Research Program currently conducts research to enable advanced composites for weight reduction while simultaneously improving damage tolerance. The goal of the Pultruded Rod Stitched Efficient Unitized Structure (PRSEUS) research effort is to demonstrate that stitching technology is an efficient approach to building lightweight, damage arresting, unitized structures to reduce part count while providing the improved mechanical load-carrying capability needed to enable improved airframe efficiency through concepts such as high aspect ratio wings and alternate architectures. However, there is limited research on the long-term aging aspects or repair of this type of structure.

What type of research could help us better understand how operating fluids and mechanical loads interact with composite materials over time? Is this type of research currently being performed? If not, why not?

NASA does not conduct research specifically focused on the long-term interaction of operating fluids with composite structures. Such research is best accomplished by the manufacturers of engines and aircraft. The safety-related research described above also helps us better understand how mechanical loads interact with composite materials over time.

For the past several decades NASA has been engaged with partners in academia and industry to develop new technology in composites. A general limitation on the advancement of composites technology is the inability of the aeronautics community to accelerate the design and certification processes for composite structures and materials. There is significant potential in increasing our efforts to apply computational analysis techniques to the design of composite materials and structures. Improved computer models would enable the community to eliminate a significant portion of the testing currently required to develop and certify composite structures, thereby greatly reducing the time and expense of developing these new materials and structures.

7. What areas of aviation safety research do you consider the most promising that could lead to new capabilities in the next five to 10 years and why?

The aviation community is investigating potential future risks and proactively managing increasing system complexity, while at the same time continuously seeking to maintain and improve safety, by mitigating known hazardous conditions and keeping vehicles healthy. As a member of the community, NASA research is supporting these issues with new capabilities.

NextGen's ability to provide the benefits of reduced fuel, emissions, and delays, will depend on advanced systems and operation capabilities. The verification and validation of these complex systems is an integral part of the system safety assurance process. With current methods, verification and validation can cost more than all other design and implementation costs combined, effectively prohibiting advancements, which would otherwise increase operational safety and efficiency while reducing environmental impact. NASA research will provide verification and validation tools, methods, and technologies that are essential for FAA and industry to enable those NextGen innovations.

In order to maintain and improve on the aviation system's excellent safety record, the community is relying on data mining to understand current and future hazards and risks before they can become serious. NASA has developed data mining algorithms and concepts for system-wide knowledge discovery that have already produced capabilities and are being utilized by aviation operators and the FAA. NASA's aviation safety researchers will continue to push the state-of-the art in order to enable the automated discovery of precursors to aviation safety incidents by mining massive heterogeneous (i.e.: discrete, numerical, and textual) data sets.

One example of understanding a future risk is flight through high ice-water content clouds. Although no accidents have been caused by it, incidents in which turbofan engines' operation is interrupted due to flight through ice crystals in high ice-water content clouds have occurred. A proactive team, involving NASA, the FAA, other government agencies and manufacturers, is currently developing the knowledge base to characterize conditions of high ice-water content and understand its accretion on engines. This will also support NASA's development of analysis tools and ground simulation capabilities, which will be used by the FAA and manufacturers to support their engine icing certification requirements in the future.

The transition to NextGen will also include new operational scenarios and an increased role for automation, and thus pilots' interaction with automated systems will change. NASA research into enabling pilots to better understand and respond with correct decisions in complex situations will provide the community with design concepts and guidelines for advanced cockpit systems that improve situation awareness and proper engagement with automation. These future capabilities will be important to realizing NextGen.

New or emerging hazards are not the only ones being addressed. Flight conditions leading to loss-of-control have been under scrutiny for some time. Current airline flight crew training simulators are not certified nor validated for out-of-envelope flight conditions (i.e.: upsets and fully developed aerodynamic stalls). Consequentially, current training only emphasizes stall recognition, rather than recovery. NASA's research in the state-of-the-art of aerodynamic modeling, including extensive wind tunnel testing, will provide an aerodynamic database and model under these conditions for application to flight simulators. This will enable historical changes in pilot training for prevention of loss-of-control accidents due to inadvertent aerodynamic stall.

While the safety record of modern aircraft systems is excellent and they are designed so that precursors to failure are found during periodic inspections, real-time knowledge and diagnosis of vehicle and system health on new and existing designs is important. NASA and its partners are evaluating structural and gas-path sensors, sensor management systems, and performance algorithms inside an engine under realistic operating conditions. Upon completion of a series of tests, advanced capabilities to diagnosis the state of engine health will be demonstrated in a relevant environment to the partners who are also end-users of the technologies.

QUESTIONS FOR DR. ABDALATI
04.19.12 Committee on Energy and Natural Resources

FROM SENATOR BINGAMAN

Question 1:

There are many questions about how reliable sea level projections are. Can you describe in more detail the strengths and limitations of the models and also how best decision-makers should use the information that is available for future planning.

Answer 1:

Two methods have been used for projecting sea level rise. The first is through models that seek to accurately describe the physics that affect sea level changes. These include expansion of oceans as they warm, the physics associated with the movement, melting, and accumulation of glaciers and ice sheets, and the variability in stored groundwater. These models have the strength of being physically based, enabling a representation of the underlying causes of sea level rise. They have the limitation, however, of not being able to fully capture the effects of changes in the flow rates of glaciers on ice sheets, which can contribute substantial amounts to sea level, as a result, this approach, while grounded in physics has historically underestimated sea level rise, and has historically not been able to capture the accelerating ice loss from ice sheets.

The second method is to compare past temperatures to past sea levels reconstructed from the geological record of Earth's climate history. There is a fairly robust relationship between the two, and by using this relationship or correlation; one can predict values of sea level rise for estimated values of future temperatures. This method is a statistical, rather than a physical approach, and when applied to future warming scenarios, this method provides the highest estimates (2 meters) for the end of the century. It has the advantage of not requiring a detailed understanding of the complex physics in order to make a prediction, and it produces results consistent with recent history. However, because it does not directly incorporate underlying physical processes, this method provides limited insight into mechanisms and characteristics of future sea level rise.

Despite the limitations, all of the many peer-reviewed, science-based sea-level models predict that sea-level rise will continue for the foreseeable future, although the models differ as to the precise rate of the average rise, and most models have underestimated current rates of sea level rise.

In addition, there is considerable regional variability in the rate of sea level rise, which makes prediction at a particular location very difficult. This variability is a result of ocean circulation characteristics, changes in land processes and characteristics in different regions, the Earth's rotational characteristics, the sources of sea level rise, etc.

For the purpose of supporting decision-making, the key points to keep in mind are as follows:

- the projections have a very wide range of uncertainty;
- they historically have underestimated rates of sea level rise, largely because there are some physical processes associated with rapid ice loss that the community is just beginning to get a handle on;
- there is considerable regional variability, such that local values may be much higher or lower than the global average, which is currently 3.1±0.4 mm/yr.;
- improving the projections requires continued acquisition and analysis of data on sea levels, ocean characteristics, ice sheets, glaciers, and groundwater storage, and continued improvements in models through the analysis and incorporation of these data.
- Besides scientific uncertainties, some of which are mentioned above, uncertainty in future greenhouse gas emissions also contributes to uncertainty in future sea level rise.

NASA, in conjunction with our partner agencies, both domestically and internationally, continues to invest in the observations and analysis that support current assessments and future predictions of sea level rise, both globally and regionally.

Question 2:

Opponents of policies to reduce carbon emissions often cite the costs and economic burden of such policies as a main reason for their opposition. Your testimony here today would indicate that the costs of inaction, and also of not planning for a certain level of climate change that we have already committed to, are quite high. Are there studies that effectively quantify these costs, and if so, how do they compare to the costs of being proactive?

Answer 2:

There is an urgent need to better estimate the economic costs of climate change; without such estimates the cost-effectiveness of measures to mitigate or adapt to climate change cannot properly be assessed.

Economic analysis is out of the purview of NASA's mission. This type of cost estimate should be performed as part of the National Climate Assessments (http://www.globalchange.gov/what-we-do/assessment) that have been conducted by the US Global Change Research Program and which can be found at http://library.globalchange.gov/. However, due to a lack of capacity, both past Assessments and the ongoing Assessment (scheduled for completion in 2013) include very little economic analysis.

Question 3:

Are there particular power plants or other pieces of energy infrastructure that are of primary concern? Is it feasible to protect them, or will they simply need to be retired or replaced?

Answer 3:

The protection our domestic energy infrastructure is critical to national safety, security and the livelihood of many Americans. The vulnerability is a combination of the amount of sea level rise, climate and weather patterns in the vicinity of these components of the infrastructure, the elevation and the surrounding landscape of where they are situated, and the resilience of these structures. NASA's efforts and expertise in sea level focus on the magnitude and distribution of sea level rise, which can inform risk assessments, however, determining the vulnerability is beyond the scope of the agency's activities.

From Senator Murkowski

1) Tools for Fixing the Problem

In Congress, it has become apparent that cap-and-trade lacks the support needed to pass, and internationally, the U.N. has failed to develop a treaty that all nations are willing to ratify. What we are left with at the moment are regulations by the EPA under the Clean Air Act, which many of us oppose due to our concerns about their economic impact.

a. How much of a difference will CAFE standards and New Source Performance Standards for power plants actually have on projected sea level rise?

Answer: There is no question that international and domestic regulatory policies will influence the future state of sea level; however, the relative impact on future sea level rise of CAFE standards and New Source Performance Standards in particular lies outside the current scope of NASA scientific research. Of course, these regulations also have beneficial effects on air quality and human health, and CAFÉ standards are projected to save consumers $1.7 trillion in fuel costs over the life of the program.

2) Setting Priorities

A New York Times article from 2007, entitled "Feel Good vs. Do Good on Climate," brings up a number of interesting points on this subject. Using New York as a case in point, the article states that "The warming that has already occurred locally is on the same scale as what's expected globally in the next century." Bjorn Lomborg is also quoted as saying, "No historian would look back at the last two centuries and rank the rising sea level here as one of the city's major problems."

a. In comparison to malaria, famine, and other global problems that are affecting people right now, how much attention should be paid to rising sea levels?

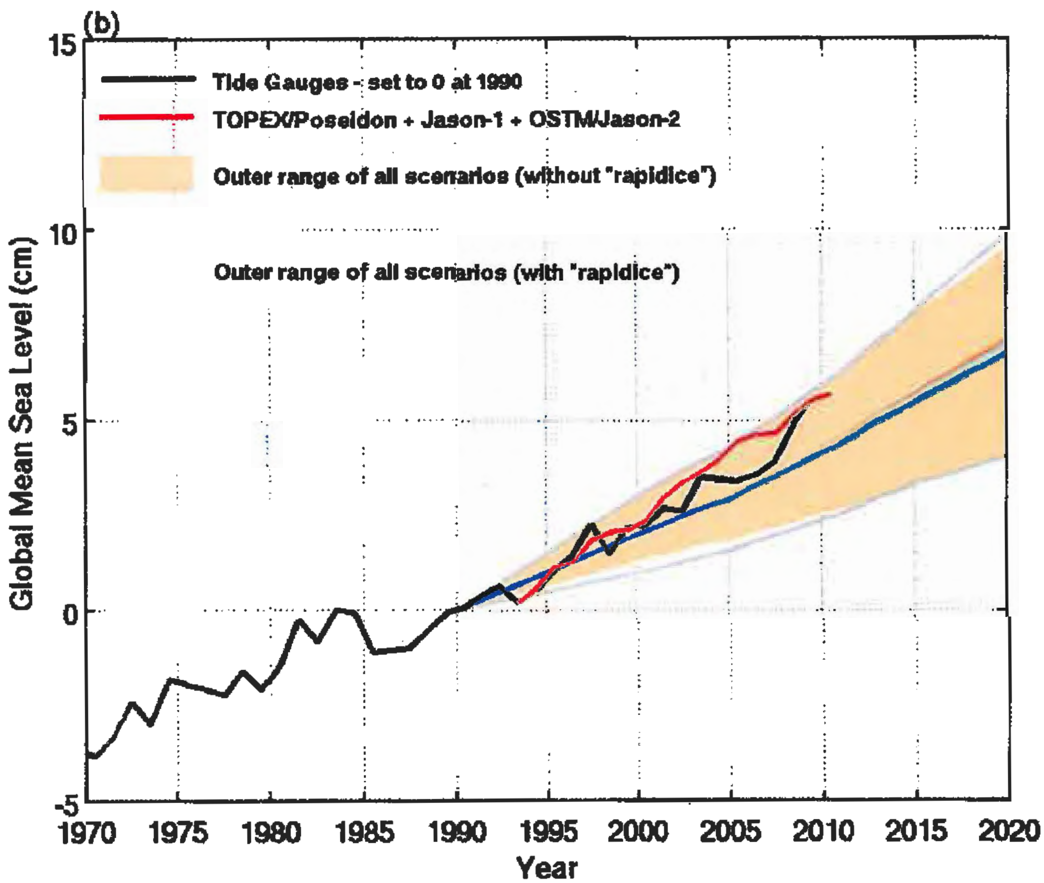
Answer: Sea level rise is one of many global challenges people face right now, in the United States and elsewhere. Each of these challenges has major implications and should be regarded as matters of great importance by the public, the science community, and policy makers. The relative urgency of one problem over another depends on the values we place on life and property, the degree of threat posed by each one, and the risks we as a nation are willing to take. In the United States, sea level rise is very likely to adversely affect the well-being of many of our citizens, and come at a great cost in terms of property and infrastructure. Deferred action on the sea level and climate change fronts means the costs of adapting will be great. Assessing how the sea level threat compares to the other threats humans face depends on information and accurate models. At NASA we continue to acquire this information, and use it to inform models, so that the risks and vulnerabilities can be appropriately assessed.

3) ACCURACY TO DATE

Scientists and researchers have been making projections about sea level rise for years – if not decades. Climate models are constantly being re-worked, and refined, but hearings like these provide an opportunity to look back as well as forward.

a. To the extent that past projections were made for sea level rise in 2010, 2012, or another point around the current period, how accurate have those projections been?

Answer: Past projections of sea level rise have typically underestimated the observed rate of rise. The figure below is taken from Church et al., Oceanography, 2011 and shows a comparison of projections from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Sea level projections from this report were matched with observations in the year 1990. The range of projections is shown by the orange band and the beige lines. For the beige lines, an attempt was made to account for a more rapid loss of ice from the ice sheets in light of rapid changes in glacier flow that the climate models could not simulate. Nevertheless, the observations from tide gauges (black line) and from satellite altimeters (red line) fall near the top of all projections.



Reference:

Church, J. A., J. M. Gregory, N. J. White, S. M. Platten, and J. X. Mitrovica, Understanding and Projecting Sea Level Change, Oceanography, 24(2), pp. 130-143.

4) LETTER FROM FORMER NASA OFFICIALS

On March 28th, your agency's Administrator, Charles Bolden, received a letter from approximately 50 former NASA officials. The letter asked that NASA "refrain from including unproven and unsupported remarks" in climate-related statements. The letter also mentions "catastrophic forecasts," and I want to ask you about that characterization. As with any prediction of future events, estimating sea levels over the next century is a decidedly difficult task. And it is made more complicated when attempts to forecast specific consequences – to infrastructure, people, or wildlife – are involved.

a. My question is: how important do you feel it is to be clear and transparent about the range of uncertainty associated with these types of predictions?

Answer: It is not merely important, but it is absolutely essential that scientists provide clear characterizations of uncertainty when making predictions about the range of possible future scenarios. If scientists are not transparent about uncertainty it diminishes both the credibility and utility of the results. This is why both the IPCC Assessments and the peer-reviewed literature upon which they are based make such extensive efforts to include characterizations of uncertainty that are rigorous, transparent, and use carefully-defined terminology.

It is equally important to remember that while we cannot precisely predict the future, we can make informed estimates based on past and current observations, and our knowledge of physical processes. Therefore, the path to decreasing uncertainty is through observations, and continuously improving our understanding of the physical processes that drive the Earth system. It is also important to remember that, no matter how good our science may become, future climate will *always* be uncertain because it depends on future human actions.

Unfortunately, in a world where discussion seems to revolve around extremes, some use uncertainty to imply doubt, and subsequently offer it as a reason for inaction. In fact, uncertainty implies the possibility of higher risk, and can be used to support the case for stronger, not weaker, action to minimize risk. None-the-less, for policy to be informed, and for the dialogue on the topic to be honest, scientists must continue to be as clear about what we don't know, as we are about what we believe to be the case.

FROM SENATOR CANTWELL

Question 1:

Knowing the responsibilities states, cities, and localities already have and their limited ability to raise additional resources, it seems like we are going to have to establish some sort of federal program that can direct the billions of dollars needed to adapt our nation's infrastructure to and protect our citizens from the impacts of climate change.

a. Do you believe such a Federal role and funding stream is necessary?

b. Wouldn't a price on carbon, which could serve to both reduce the severity of these climate impacts and provide the needed funds, make the most sense?

Answer 1a&b:

As I stated in this hearing, the climate has always changed. It always will, for a variety of reasons. The success of society in the face of those changes really depends on how big the changes are, how rapidly they occur, and our ability to anticipate and prepare for them. There is a significant level of federally funded research under way targeted at determining what the future will likely bring, so that we can be equipped to prepare for the changes that lie ahead. What is learned through this research can also inform policies targeted at slowing and reducing the change, to levels that can be more easily adapted to. The federal government plays a critical role in developing the necessary knowledge to successfully confront the challenges associated with climate change, and this must continue. Placing a price on carbon is one tool that can be used to incentivize people to find alternative forms of energy that may have less of an impact on our environment and sea level. The effectiveness of this approach, and how it compares to others is not clear, and is not something NASA is involved in studying. What is clear, however, is that the reliable evaluation of this effectiveness requires an understanding of the physical processes at work, which is where the contributions from the NASA investments are critical.

Question 2:

As we think about our economic and energy future, we need to consider the real costs of inaction. A recent study has estimated that the impacts of climate change will cost my home state of Washington 10 billion dollars per year by 2020. This is an enormous burden that will be arriving very soon.

It is imperative that we get ahead of this curve and prepare for these impacts now. To that end, we must maintain vital funding of research programs and facilities that advance scientific knowledge and understanding and provide the foundation for cost-effective, innovative solutions. Unfortunately, funding carve-outs in the Department of Energy's Office of Science have impacted base program funding for user facilities and research in recent years.

In my home state, PNNL is working on solutions to the challenges climate change imposes, but to succeed, they need our continued support. In these fiscally austere times, it makes even less sense to be a penny wise and a pound foolish. PNNL is conducting important research, for example through the Atmospheric Radiation Measurement (ARM) Program, to get a better sense of what changes in climate are already occurring and will likely occur in the future – advancing our understanding of the climate system that include complex components such as aerosols, clouds, and the carbon cycle.

PNNL is also working to provide better information to plan for the coming impacts. They're developing high-resolution models that incorporate critical infrastructure and natural resources of each region to inform mitigation and adaptation decisions at the state and regional level. This information will be invaluable for infrastructure planning by natural resource managers, energy companies, and government agencies that currently face great uncertainties in their decision making in response to changing regional climates.

It seems to me that the upfront costs of this research and planning will be extremely modest relative to the costs coming down the road.

a. Do all of you agree that proposed cuts to research and development will impede our ability to prepare for and mitigate the worst impacts of climate change?

Answer 2a:

For decades our nation's investment in research and development has led to great advances in our understanding of, and ability to predict, sea level rise and climate change. Continued commitment to research and development will no doubt lead to more robust climate predictions and predictions of future sea level rise, and will increase our ability to successfully deal with climate change. In these challenging fiscal times, it is the difficult task of our nation's policy makers to balance the need for these investments against other challenges we face. We at NASA work hard to maximize the science return on that investment, no matter its size.

b. Do you hear from states and localities appreciating your analysis and that they use your data to make better planning decisions?

Answer 2b:

NASA's Earth Science Division includes an Applied Sciences Program, which partners with public and private organizations such as state and local governments on ways to incorporate NASA Earth observational data and science results in their decision-making activities and services. These have proven to be both valuable and appreciated. Some examples of these successful collaborations are given below.

New Mexico Department of Health Utilizes NASA Satellite Products for Dust Storm Forecasting

A NASA-funded project with the New Mexico Department of Health (DoH) led to the production of daily 48-hour dust forecasts drawing on observations from MODIS and CALIPSO. Dust storms are known to trigger asthmatic responses and cardiovascular issues in susceptible individuals. These forecasts are available to the public and end-users throughout the state via the New Mexico DoH web portal (http://nmtracking.unm.edu) and are also linked to the national CDC Environmental Public Health Tracking Network (EPHTN).

NASA/ARRA Project aids California Agricultural Community

Agricultural uses of water account for more than 80% of total water consumption in many Western states, and optimization of irrigation management is a key component of sustaining agricultural water supplies. Knowing how much and when to irrigate can be a complicated and costly decision. Through American Reinvestment and Recovery Act (ARRA) funds, NASA worked with California Department of Water Resources (CDWR) on a project to apply NASA Earth satellite observations in the California Irrigation Management Information System (CIMIS). The project integrated NASA Terra, Aqua, and Landsat satellite measurements with agricultural weather conditions from CIMIS to map key indicators of crop water requirements and agricultural irrigation demand across the entire California Central Valley at the scale of individual fields on a daily basis. The project produced estimates of crop water needs for each field, providing a new source of information that can be used by growers to account for optimal irrigation rates when scheduling irrigation. NASA and CDWR worked with grower associations and individual growers in the project.

NASA's GRACE Data Enhances the U.S. Drought Monitor

The U.S. Drought Monitor provides weekly maps of national vulnerability to drought, supporting state and local effort to focus on preparedness and risk management to manage water supply and deliver drought aid where it is needed most. A project sponsored by NASA's Earth Science Division integrated data products from the GRACE (Gravity Recovery and Climate Experiment) satellite to enhance the U.S. Drought Monitor. The project combined GRACE data and other observations to improve information on soil moisture and groundwater records, which are used to produce weekly maps of wetness conditions in the soil and aquifers. Prior to the addition of the new GRACE-based products, the US Drought Monitor lacked information on deep soil moisture and groundwater storage – water resources that can be used to gauge the impacts of long episodes of wet or dry weather.

> *"These maps provide regional to national-level water resource information that was previously unavailable to policy and decision-makers. The novel use of satellite-based gravity data in combination with advanced modeling techniques has given us a unique perspective on groundwater that was not resolvable through just ground-based observations that can provide new information for hydrologic drought monitoring."*
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> *"We have traditional estimates of carbon flux based on inventory plots, but [the project's] data integrates the physiological functions of forest ecosystems with state-of-the-art landscape modeling, satellite remote sensing, large-scale vegetation mapping, and computer simulation. [The project] uses the technology investments of NASA and puts them into a useful format to help us better understand the annual flux of carbon through Oregon forests."*
> *Andrew Yost, Oregon Department of Forestry*

Question 3:

Shellfish farmers in Washington State are being severely impacted by ocean acidification. In Washington, the shellfish industry employs over 3,200 Washingtonians and has a total economic contribution of $270 million annually.

In 2010, I secured funding to acquire and deploy ocean acidification sensors near major shellfish hatcheries in Washington State. Today, these sensors, combined with buoys from NOAA's Integrated Ocean Observation System program, allow shellfish growers to monitor ocean acidity in real time. Real time ocean acidification data has made all the difference to the shellfish industry, illustrating a strong nexus between ocean acidification data and shellfish recruitment. Without real time monitoring, the shellfish industry cannot survive.

a. Dr. Abdalati, are we getting close to having reliable satellite data on the acidity of the ocean like we do for sea surface temperature?

Answer 3a:

Yes, we are getting closer. However, it is not yet possible to directly measure the acidity of the ocean from space. It is possible to estimate some properties of the ocean related to ocean acidity (or pH, a measure of acidity or basicity of an aqueous solution, in this case, the ocean) and the biological, chemical, and ecological impacts of changing ocean acidity from what are known as "ocean color" satellites. Properties of the ocean related to ocean acidity and the impacts of ocean acidification on ocean biology that can be estimated from "ocean color" satellites include new data products such as particulate inorganic carbon (PIC), biogenic silica, and the partial pressure of carbon dioxide (pCO2), as well as standard products such as phytoplankton chlorophyll (chl).

"Ocean color" sensors can measure light coming from the ocean in the ultraviolet to infrared portions of the electromagnetic spectrum. The light coming from the ocean is referred to as the ocean's optical properties or "color", and can provide quantitative, detailed information on the ocean's biology, ecology, and chemistry. Researchers can use ocean color satellite data of the optical properties of the ocean to estimate or model ocean acidity indirectly, as well as the biological impacts of ocean acidification. For example, recently-published NASA-funded research has developed a method for predicting coastal surface-water pCO_2 (partial pressure of carbon dioxide, or CO_2) from remote-sensing data, based on self organizing maps and a nonlinear semi-empirical model of surface water carbonate chemistry (Hales et al., 2012, in press, Progress in Oceanography). In the ocean, the pCO2 is determined from measurements of two of the following: dissolved inorganic carbon, pH and alkalinity. pCO2 in the ocean can change based on location (sampling depth, latitude), ocean temperature, and the ocean's alkalinity (or measure of the ocean's capacity to balance acid, such as hydrogen ions, with base, such as carbonate ions). Biological processes in the ocean also influence the pCO2 in the ocean. While this algorithm is experimental, this type of study not only gives us insight in to what properties from ocean color satellites can be used to estimate ocean acidity regionally and globally, but also provides quantitative information on carbon cycling.

b. What monitoring sensors and algorithms are still needed to observe the acidification of the ocean remotely from satellites?

Answer 3b:

Continued observations from NASA satellite ocean color sensors will provide data on properties of the ocean such as phytoplankton chlorophyll (proxy for ocean plants), which help to detail ecological impacts of ocean acidification on "primary producers" (bottom of the food chain). Understanding the impacts of ocean acidification on the primary trophic level will allow researchers and managers to identify and understand the impacts of ocean acidification on higher trophic levels (e.g., fisheries) that depend on primary producers for food. Satellites can provide this information from a local to a global scale. Continuity of ocean color data from past sensors such as the Sea-Viewing Wide Field-of-view Sensor (SeaWiFS), and existing sensors such as the Moderate resolution Imaging Spectroradiometer (MODIS), and perhaps future data from the Suomi NPP VIIRS (Visible Infrared Imager Radiometer Suite) are critical to providing a time series of biological data in the ocean critical for detailing the response of the ocean's biology and ecology to ocean acidification.

QUESTIONS FOR DR. ABDALATI
04.19.12 Committee on Energy and Natural Resources

<u>FROM SENATOR BINGAMAN</u>

Question 1:

There are many questions about how reliable sea level projections are. Can you describe in more detail the strengths and limitations of the models and also how best decision-makers should use the information that is available for future planning.

Answer 1:

Two methods have been used for projecting sea level rise. The first is through models that seek to accurately describe the physics that affect sea level changes. These include expansion of oceans as they warm, the physics associated with the movement, melting, and accumulation of glaciers and ice sheets, and the variability in stored groundwater. These models have the strength of being physically based, enabling a representation of the underlying causes of sea level rise. They have the limitation, however, of not being able to fully capture the effects of changes in the flow rates of glaciers on ice sheets, which can contribute substantial amounts to sea level, as a result, this approach, while grounded in physics has historically underestimated sea level rise, and has historically not been able to capture the accelerating ice loss from ice sheets.

The second method is to compare past temperatures to past sea levels reconstructed from the geological record of Earth's climate history. There is a fairly robust relationship between the two, and by using this relationship or correlation; one can predict values of sea level rise for estimated values of future temperatures. This method is a statistical, rather than a physical approach, and when applied to future warming scenarios, this method provides the highest estimates (2 meters) for the end of the century. It has the advantage of not requiring a detailed understanding of the complex physics in order to make a prediction, and it produces results consistent with recent history. However, because it does not directly incorporate underlying physical processes, this method provides limited insight into mechanisms and characteristics of future sea level rise.

Despite the limitations, all of the many peer-reviewed, science-based sea-level models predict that sea-level rise will continue for the foreseeable future, although the models differ as to the precise rate of the average rise, and most models have underestimated current rates of sea level rise.

In addition, there is considerable regional variability in the rate of sea level rise, which makes prediction at a particular location very difficult. This variability is a result of ocean circulation characteristics, changes in land processes and characteristics in different regions, the Earth's rotational characteristics, the sources of sea level rise, etc.

For the purpose of supporting decision-making, the key points to keep in mind are as follows:

- the projections have a very wide range of uncertainty;
- they historically have underestimated rates of sea level rise, largely because there are some physical processes associated with rapid ice loss that the community is just beginning to get a handle on;
- there is considerable regional variability, such that local values may be much higher or lower than the global average, which is currently 3.1 ± 0.4 mm/yr.;
- improving the projections requires continued acquisition and analysis of data on sea levels, ocean characteristics, ice sheets, glaciers, and groundwater storage, and continued improvements in models through the analysis and incorporation of these data.
- Besides scientific uncertainties, some of which are mentioned above, uncertainty in future greenhouse gas emissions also contributes to uncertainty in future sea level rise.

NASA, in conjunction with our partner agencies, both domestically and internationally, continues to invest in the observations and analysis that support current assessments and future predictions of sea level rise, both globally and regionally.

Question 2:

Opponents of policies to reduce carbon emissions often cite the costs and economic burden of such policies as a main reason for their opposition. Your testimony here today would indicate that the costs of inaction, and also of not planning for a certain level of climate change that we have already committed to, are quite high. Are there studies that effectively quantify these costs, and if so, how do they compare to the costs of being proactive?

Answer 2:

There is an urgent need to better estimate the economic costs of climate change; without such estimates the cost-effectiveness of measures to mitigate or adapt to climate change cannot properly be assessed.

Economic analysis is out of the purview of NASA's mission. This type of cost estimate should be performed as part of the National Climate Assessments (http://www.globalchange.gov/what-we-do/assessment) that have been conducted by the US Global Change Research Program and which can be found at http://library.globalchange.gov/. However, due to a lack of capacity, both past Assessments and the ongoing Assessment (scheduled for completion in 2013) include very little economic analysis.

Question 3:

Are there particular power plants or other pieces of energy infrastructure that are of primary concern? Is it feasible to protect them, or will they simply need to be retired or replaced?

Answer 3:

The protection our domestic energy infrastructure is critical to national safety, security and the livelihood of many Americans. The vulnerability is a combination of the amount of sea level rise, climate and weather patterns in the vicinity of these components of the infrastructure, the elevation and the surrounding landscape of where they are situated, and the resilience of these structures. NASA's efforts and expertise in sea level focus on the magnitude and distribution of sea level rise, which can inform risk assessments, however, determining the vulnerability is beyond the scope of the agency's activities.

From Senator Murkowski

1) Tools for Fixing the Problem

In Congress, it has become apparent that cap-and-trade lacks the support needed to pass, and internationally, the U.N. has failed to develop a treaty that all nations are willing to ratify. What we are left with at the moment are regulations by the EPA under the Clean Air Act, which many of us oppose due to our concerns about their economic impact.

a. How much of a difference will CAFE standards and New Source Performance Standards for power plants actually have on projected sea level rise?

Answer: There is no question that international and domestic regulatory policies will influence the future state of sea level; however, the relative impact on future sea level rise of CAFE standards and New Source Performance Standards in particular lies outside the current scope of NASA scientific research. Of course, these regulations also have beneficial effects on air quality and human health, and CAFÉ standards are projected to save consumers $1.7 trillion in fuel costs over the life of the program.

2) Setting Priorities

A New York Times article from 2007, entitled "Feel Good vs. Do Good on Climate," brings up a number of interesting points on this subject. Using New York as a case in point, the article states that "The warming that has already occurred locally is on the same scale as what's expected globally in the next century." Bjorn Lomborg is also quoted as saying, "No historian would look back at the last two centuries and rank the rising sea level here as one of the city's major problems."

a. In comparison to malaria, famine, and other global problems that are affecting people right now, how much attention should be paid to rising sea levels?

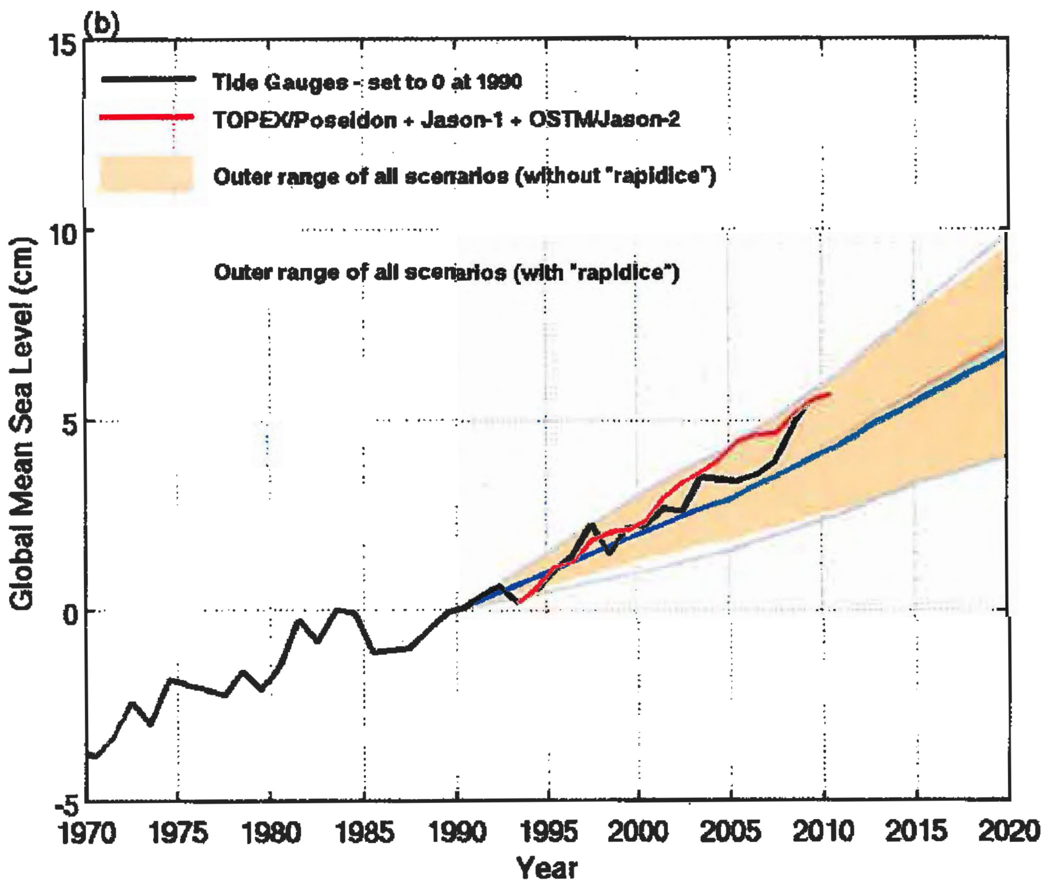
Answer: Sea level rise is one of many global challenges people face right now, in the United States and elsewhere. Each of these challenges has major implications and should be regarded as matters of great importance by the public, the science community, and policy makers. The relative urgency of one problem over another depends on the values we place on life and property, the degree of threat posed by each one, and the risks we as a nation are willing to take. In the United States, sea level rise is very likely to adversely affect the well-being of many of our citizens, and come at a great cost in terms of property and infrastructure. Deferred action on the sea level and climate change fronts means the costs of adapting will be great. Assessing how the sea level threat compares to the other threats humans face depends on information and accurate models. At NASA we continue to acquire this information, and use it to inform models, so that the risks and vulnerabilities can be appropriately assessed.

3) Accuracy to Date

Scientists and researchers have been making projections about sea level rise for years – if not decades. Climate models are constantly being re-worked, and refined, but hearings like these provide an opportunity to look back as well as forward.

a. To the extent that past projections were made for sea level rise in 2010, 2012, or another point around the current period, how accurate have those projections been?

Answer: Past projections of sea level rise have typically underestimated the observed rate of rise. The figure below is taken from Church et al., Oceanography, 2011 and shows a comparison of projections from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Sea level projections from this report were matched with observations in the year 1990. The range of projections is shown by the orange band and the beige lines. For the beige lines, an attempt was made to account for a more rapid loss of ice from the ice sheets in light of rapid changes in glacier flow that the climate models could not simulate. Nevertheless, the observations from tide gauges (black line) and from satellite altimeters (red line) fall near the top of all projections.



Reference:

Church, J. A., J. M. Gregory, N. J. White, S. M. Platten, and J. X. Mitrovica, Understanding and Projecting Sea Level Change, Oceanography, 24(2), pp. 130-143.

4) Letter from Former NASA Officials

On March 28th, your agency's Administrator, Charles Bolden, received a letter from approximately 50 former NASA officials. The letter asked that NASA "refrain from including unproven and unsupported remarks" in climate-related statements. The letter also mentions "catastrophic forecasts," and I want to ask you about that characterization. As with any prediction of future events, estimating sea levels over the next century is a decidedly difficult task. And it is made more complicated when attempts to forecast specific consequences – to infrastructure, people, or wildlife – are involved.

a. My question is: how important do you feel it is to be clear and transparent about the range of uncertainty associated with these types of predictions?

Answer: It is not merely important, but it is absolutely essential that scientists provide clear characterizations of uncertainty when making predictions about the range of possible future scenarios. If scientists are not transparent about uncertainty it diminishes both the credibility and utility of the results. This is why both the IPCC Assessments and the peer-reviewed literature upon which they are based make such extensive efforts to include characterizations of uncertainty that are rigorous, transparent, and use carefully-defined terminology.

It is equally important to remember that while we cannot precisely predict the future, we can make informed estimates based on past and current observations, and our knowledge of physical processes. Therefore, the path to decreasing uncertainty is through observations, and continuously improving our understanding of the physical processes that drive the Earth system. It is also important to remember that, no matter how good our science may become, future climate will *always* be uncertain because it depends on future human actions.

Unfortunately, in a world where discussion seems to revolve around extremes, some use uncertainty to imply doubt, and subsequently offer it as a reason for inaction. In fact, uncertainty implies the possibility of higher risk, and can be used to support the case for stronger, not weaker, action to minimize risk. None-the-less, for policy to be informed, and for the dialogue on the topic to be honest, scientists must continue to be as clear about what we don't know, as we are about what we believe to be the case.

FROM SENATOR CANTWELL

Question 1:

Knowing the responsibilities states, cities, and localities already have and their limited ability to raise additional resources, it seems like we are going to have to establish some sort of federal program that can direct the billions of dollars needed to adapt our nation's infrastructure to and protect our citizens from the impacts of climate change.

a. Do you believe such a Federal role and funding stream is necessary?

b. Wouldn't a price on carbon, which could serve to both reduce the severity of these climate impacts and provide the needed funds, make the most sense?

Answer 1a&b:

As I stated in this hearing, the climate has always changed. It always will, for a variety of reasons. The success of society in the face of those changes really depends on how big the changes are, how rapidly they occur, and our ability to anticipate and prepare for them. There is a significant level of federally funded research under way targeted at determining what the future will likely bring, so that we can be equipped to prepare for the changes that lie ahead. What is learned through this research can also inform policies targeted at slowing and reducing the change, to levels that can be more easily adapted to. The federal government plays a critical role in developing the necessary knowledge to successfully confront the challenges associated with climate change, and this must continue. Placing a price on carbon is one tool that can be used to incentivize people to find alternative forms of energy that may have less of an impact on our environment and sea level. The effectiveness of this approach, and how it compares to others is not clear, and is not something NASA is involved in studying. What is clear, however, is that the reliable evaluation of this effectiveness requires an understanding of the physical processes at work, which is where the contributions from the NASA investments are critical.

Question 2:

As we think about our economic and energy future, we need to consider the real costs of inaction. A recent study has estimated that the impacts of climate change will cost my home state of Washington 10 billion dollars per year by 2020. This is an enormous burden that will be arriving very soon.

It is imperative that we get ahead of this curve and prepare for these impacts now. To that end, we must maintain vital funding of research programs and facilities that advance scientific knowledge and understanding and provide the foundation for cost-effective, innovative solutions. Unfortunately, funding carve-outs in the Department of Energy's Office of Science have impacted base program funding for user facilities and research in recent years.

In my home state, PNNL is working on solutions to the challenges climate change imposes, but to succeed, they need our continued support. In these fiscally austere times, it makes even less sense to be a penny wise and a pound foolish. PNNL is conducting important research, for example through the Atmospheric Radiation Measurement (ARM) Program, to get a better sense of what changes in climate are already occurring and will likely occur in the future – advancing our understanding of the climate system that include complex components such as aerosols, clouds, and the carbon cycle.

PNNL is also working to provide better information to plan for the coming impacts. They're developing high-resolution models that incorporate critical infrastructure and natural resources of each region to inform mitigation and adaptation decisions at the state and regional level. This information will be invaluable for infrastructure planning by natural resource managers, energy companies, and government agencies that currently face great uncertainties in their decision making in response to changing regional climates.

It seems to me that the upfront costs of this research and planning will be extremely modest relative to the costs coming down the road.

a. Do all of you agree that proposed cuts to research and development will impede our ability to prepare for and mitigate the worst impacts of climate change?

Answer 2a:

For decades our nation's investment in research and development has led to great advances in our understanding of, and ability to predict, sea level rise and climate change. Continued commitment to research and development will no doubt lead to more robust climate predictions and predictions of future sea level rise, and will increase our ability to successfully deal with climate change. In these challenging fiscal times, it is the difficult task of our nation's policy makers to balance the need for these investments against other challenges we face. We at NASA work hard to maximize the science return on that investment, no matter its size.

b. Do you hear from states and localities appreciating your analysis and that they use your data to make better planning decisions?

Answer 2b:

NASA's Earth Science Division includes an Applied Sciences Program, which partners with public and private organizations such as state and local governments on ways to incorporate NASA Earth observational data and science results in their decision-making activities and services. These have proven to be both valuable and appreciated. Some examples of these successful collaborations are given below.

New Mexico Department of Health Utilizes NASA Satellite Products for Dust Storm Forecasting

A NASA-funded project with the New Mexico Department of Health (DoH) led to the production of daily 48-hour dust forecasts drawing on observations from MODIS and CALIPSO. Dust storms are known to trigger asthmatic responses and cardiovascular issues in susceptible individuals. These forecasts are available to the public and end-users throughout the state via the New Mexico DoH web portal (http://nmtracking.unm.edu) and are also linked to the national CDC Environmental Public Health Tracking Network (EPHTN).

NASA/ARRA Project aids California Agricultural Community

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b. What monitoring sensors and algorithms are still needed to observe the acidification of the ocean remotely from satellites?

Answer 3b:

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Senator Kay Bailey Hutchison
Senate Committee on Commerce, Science, and Transportation
Hearing on Risks, Opportunities, and Oversight of Commercial Space"
June 20, 2012
Questions for the Record

Bill Gerstenmaier, NASA

Commercial Orbital Transportation System - COTS

1. **Please provide details of the steps required to transition SpaceX to performance under its Commercial Resupply Services contract. Please include information regarding the review and analysis of data from what appears to have been a very successful COTS 2+3 combined demonstration flight.**

A: It is important to note that Commercial Orbital Transportation Services (COTS) and Commercial Resupply Services (CRS) are separate activities; the work under CRS is not a transition from COTS. SpaceX has been working under contract to NASA to provide cargo delivery services since SpaceX was awarded a CRS contract in December 2008. SpaceX delivered cargo under CRS during its COTS demonstration and has already completed milestones under the CRS contract for the five missions currently in process. This work has been focused in three main areas – a) cargo processing, b) mission planning and overall vehicle performance, and c) completion of the visiting vehicle safety requirements. All three of these key areas were demonstrated during the COTS demonstration mission.

SpaceX and NASA have completed several post flight reviews and lessons learned sessions reviewing the COTS demonstration mission and improvements in each of the key areas have been identified. Examples of the improvements include an updated process for review and testing of software upgrades, updates to cargo packing both on the ground and on orbit, changes in how quickly flight data will be accessible after the spacecraft has returned, and updates in telemetry and tracking. These improvements have been included into the standard verification work and mission planning that supported the first CRS mission in October 2012 and will continue to be performed prior to every CRS mission.

With the successful completion of the COTS C2+ flight, SpaceX has accomplished all objectives necessary to demonstrate they can transport cargo to the ISS and return cargo to Earth. NASA is currently reviewing post flight data with SpaceX, as has been the standard practice with all demonstration flights. Two formal reviews have taken place to date. The final review was held in August 2012 and coincided with the transmittal of the mission final report to NASA. The next flight flown in October 2012 was the first operational mission under the CRS contract.

Additionally the ISS technical and safety integration teams have been working with SpaceX since August 2006 when the COTS Space Act Agreements (SAA) began. The interactions and the information and products provided by SpaceX have been of high quality and have enabled the ISS program to safely integrate SpaceX capabilities and operations into the program.

2. **What is your confidence level regarding that the ability of the Orbital Sciences Corporation to launch its demonstration mission this year? Are there any technical concerns with the launch vehicle and/or the Cygnus system?**

A: Orbital Sciences continues to make progress in preparing their ground and flight systems for their upcoming test and demonstration flights. Critical vehicle testing on the pad is required prior to the test mission. Orbital is planning to complete the wet dress rehearsal and hot fire pad tests by the end of January. The launch of the Antares test flight will occur soon after the tests are complete. Orbital's demonstration mission to the ISS could be flown approximately 2-3 months after the Antares test flight, pending nominal pad refurbishment activities. Currently, Orbital Sciences is processing the test and demonstration flight launch vehicles and spacecraft with no major anomalies being identified. Orbital is conducting Joint Integrated simulations with the ISS program in preparation for the COTS demonstration flight as well as progressing through the ISS visiting vehicle verification process. As with the development of all complex space systems, there is always a chance of uncovering technical issues during this period but NASA and its partners will work to mitigate any issues that may arise.

3. **Can you summarize, to the extent possible, the technical issues that have impeded the launch pad development at the Wallops Island launch complex?**

A: The state of Virginia's Mid-Atlantic Regional Spaceport (MARS) is responsible for construction and operation of the launch pad that Orbital Sciences will use for their COTS demonstration as well as ISS operational flights. Pad construction has been a clean sheet effort versus refurbishing an existing facility. As pad construction progressed, technical issues arose that are not atypical with construction of extremely complex infrastructure intended to distribute fuel and super-cold oxidizer at the precise flow rates and pressures needed to support launch vehicle loading and launch. Technical challenges were discovered when these super-cold fluids were introduced into transport lines for the first time. Additionally, as pad systems were activated, problems arose that required rework and increased the timeframe needed to complete the pad. Pad turnover has now been completed.

4. **While there have been slips to Commercial Cargo demonstration flights, what is the production status for the hardware needed for follow-on cargo resupply flights, which are needed to supply ISS. Are they slipping as well or are these contractors ready to fly, once they have demonstrated their capabilities in the upcoming demonstration flights?**

A: The current ISS Flight Program includes three SpaceX and two Orbital CRS missions to ISS by the end of calendar year 2013. Production status is as follows.

- SpX-1: The Dragon launched atop a SpaceX Falcon 9 rocket from Cape Canaveral Air Force Station in Florida, on October 7, 2012. It carried 882 pounds of cargo to the complex, including 260 pounds of crew supplies, 390 pounds of scientific research, 225 pounds of hardware and several pounds of other supplies. This included critical materials to support 166 scientific investigations, of which 63 were new. Returning with the Dragon capsule was 1,673 pounds of cargo, including 163 pounds of crew supplies, 866 pounds of scientific research, and 518 pounds of hardware. Dragon splashed down in the Pacific Ocean October 28, 2012. The splashdown successfully ended the first contracted cargo delivery flight contracted by NASA to resupply the International Space Station.

- SpX-2 (FY13 Q2): The interstage, the first stage and second stage have been shipped to the Cape. The Dragon capsule and trunk are in final assembly and are planned to shipped to the Cape in December.

- SpaceX-3: This is the first CRS mission with upgraded Falcon Version 1.1. Production schedule for the new launch vehicles are being developed. The thrusters are scheduled to be complete in February 2013. The service section is planned to be mated in January with final closeout scheduled in April 2013. The dragon module has a planned completion date of May 2013. The current schedule has the Dragon capsule and trunk ready to ship to the Cape in June 2013.

- Orb-1: The first stage core of the Antares launch vehicle has been delivered to the Wallops Flight Facility (WFF). The first stage engines are scheduled for shipment to Stennis Space Center (SSC) for testing and shipment back to WFF in January 2013. The upper stack avionics cylinder is in system testing through March 2013. The Castor 30B (upper stack engine) final assembly is complete and stored awaiting a shipment due to WFF. The pressurized cargo module of Cygnus is also complete with planned delivery to WFF in April. The service module is currently undergoing Final Integrated Systems Test with shipment to WFF planned for March 2013.

- Orb-2: The current plan for the Orb-2 launch vehicle is to use the refurbished core from the 7K-test article. One first stage engine is integrated into the test article and will be refurbished and used for Orb-2 after the hot fire test. The second first stage engine is scheduled for delivery to WFF in February 2013. The upper stack avionics cylinder and payload cone are complete. The avionics system is being assembled and testing will occur from November through January 2013. The Castor 30B is in production and will ship to WFF in April. The pressurized cargo module of Cygnus is complete and integration testing is in progress. The planned delivery date to WFF is June 2013. The service module is undergoing spacecraft assembly, with the Initial Integrated System Test completed. Component testing is underway with Final Integrated System Test planned for completion in March 2013.

5. **How much cargo was transported to ISS and back to Earth during the Space X demonstration flight? How does that payload capability compare with the payload transport requirements for the full-up operational Space X system? What**

additional effort, NASA support, and resulting government funding is required to meet the payload requirements under the Space X Cargo Resupply Services contract?

A: During the May SpaceX COTS demonstration mission, the Dragon capsule delivered about 525 kilograms to the ISS as upmass under the CRS contract. On the return trip, Dragon carried science experiments to be returned to researchers. Including the experiments, Dragon returned a total of about 665 kilograms of hardware and cargo no longer needed aboard the Station as downmass under the CRS contract. The Dragon has the capacity to carry 3,200 kg of upmass internally or externally. As a practical matter, the internal carrying capacity will likely be limited by the volume available and will be about 1,600 kg. The capsule can return approximately 1,400 kg of downmass, which, at the projected 3 flights per year, should be sufficient to meet all ISS projected return requirements.

In terms of NASA support to SpaceX under the CRS contract, on December 23, 2008, the Agency ordered 12 CRS flights valued at $1.6B from SpaceX. These funds are paid to SpaceX under a milestone structure based on progress for each flight.

6. **Now that Space X has completed their cargo demonstration flights, can you tell us how much government funding, including the cost for the use of government facilities and NASA personnel expertise, was required to complete the Space X cargo vehicle development effort?**

A: Commercial Orbital Transportation Services (COTS) is the only NASA effort that directly funds the cargo vehicle development effort and NASA has provided $396M to SpaceX under the COTS Space Act Agreement. NASA also budgeted and spent approximately $40.1M through October 31, 2012, for NASA's efforts to manage and support the commercial cargo development effort. This includes the cost of government facilities and NASA personnel expertise provided through the program office. However, the NASA does not track the cost to support the individual providers, SpaceX and Orbital. Also, NASA does not track additional, indirect support provided for the cargo development effort by other Programs such as ISS.

7. **I understand that there were a large number of issues to resolve prior to this last flight by the SpaceX team. How was NASA involved in the resolution of those issues, and what level of NASA resources were required to resolve those issues? Please include figures regarding the civil servant time applied to support commercial activities?**

A: NASA's primary role is to monitor the progress of its commercial partners through an assessment of the milestones and to make payment for successfully completed milestones. NASA provides expert technical assistance; as requested or where considered necessary, via the NASA COTS Advisory Team (CAT) discipline experts drawn from across the Agency. CATs selectively support commercial partner reviews and consult on technical issues as requested. More extensive NASA support requires reimbursement for services or facility use via Reimbursable Space Act Agreements. Commercial Partners also receive ISS integration and certification support for their visiting vehicles. NASA has spent $40.1M of the funds appropriated for the COTS program since 2006 managing and supporting the COTS effort of both commercial partners, and approximately $16.8M of that cost (through October 31, 2012) is NASA civil servant labor. See Answer to question 6 for more details.

8. **According to the schedule associated with the CCDev Space Act Agreement between NASA and Space X, the recent Space X flight was almost 2-1/2 years late. Now that the demonstration phase is complete, along with government funding that went with it, will NASA hold Space X to its contractually mandated delivery schedules and other terms under the CRS firm fixed price contract they have signed?**

A: It is important to note that the Commercial Orbital Transportation Services (COTS) Space Act Agreement (SAA) with SpaceX is distinct from both the Commercial Crew Development (CCDev) SAA and the Commercial Resupply Services (CRS) cargo contract. In the case of the latter, the contract calls for the delivery of a minimum of 20 metric tons of cargo to the ISS, as well as the return or disposal of 3 metric tons of cargo from the orbiting complex. The contract is a firm-fixed price, Indefinite Delivery Indefinite Quantity procurement with a period of performance from January 1, 2009, through December 30, 2015, and NASA pays SpaceX for only those milestones that are successfully met.

When awarding the CRS contracts, NASA understood that the management of these contracts would be challenging for both NASA and the contractors. The contractors have the difficult job of producing the launch and cargo vehicles. NASA has the difficult job of orchestrating multiple missions to the ISS along with managing all of the on orbit activities. Under these conditions it is expected that schedules will be changed and both NASA and the CRS contractors have requested changes in the mission dates and consideration for the mission moves have been negotiated.

Launch windows for CRS flights to the ISS are baselined at the Vehicle Baseline Review (VBR) as provided for by the CRS contract. If SpaceX is not able to meet the contractual launch window, NASA negotiates with SpaceX an equitable adjustment to the value of the contract depending on the length and nature of the delay.

9. **NASA has committed to transitioning to firm fixed price contracts for the purchase of ISS resupply services. Fixed price contracts allocate risk of delay to the contractor, so any schedule delay should result in consideration paid to NASA. Will this in fact be the case as NASA and the ISS service providers transition to firm fixed price contracts?**

A: Please see the response to question #8, above. NASA will only pay its CRS contractors when they meet milestones. At the Vehicle Baseline Review (VBR), NASA and the contractor jointly reach agreement on a 90 day launch window. After VBR, either NASA or the contractor can request a launch delay of up to 30 days without penalty. Any delays beyond 30 days need to be negotiated and could result in an equitable adjustment, change in delivery schedule or change in the period of performance.

10. Administrator Bolden has stated that the procurement of actual ISS cargo services will be conducted under FAR-based fixed price contracts. Can you provide assurance that any future competition for either crew or cargo servicing will be under FAR-based contracts open to all bidders?

A: The procurement of actual ISS cargo services for the direct benefit of NASA were awarded as FAR-based fixed price contracts. Future competitions for both crew and cargo servicing will be awarded using competitive FAR-based contracts.

11. NASA officials and the Director of OSTP continue to state that the use of commercial services for crew and cargo transport to low Earth orbit will free up more resources for exploration beyond LEO. However, NASA continues to press for additional funding for commercial crew development, while reducing funding for SLS and Orion. Can you explain this contradiction between NASA officials' public statements and their funding requests?

A: NASA is committed to operating and utilizing the International Space Station (ISS) and preparing for the next crewed missions of exploration beyond low Earth orbit (LEO). Now that the Space Shuttle has been retired, it is important to provide funding for the development of commercial crew systems that will enable the U.S. to resume flying its astronauts to the ISS on American-made vehicles as soon as possible. Once developed, these vehicles will allow NASA to spend less on LEO crew transportation through the purchase of domestic services than would be the case if the Agency had to build, operate, and maintain its own spacecraft for this purpose. This in turn enables NASA to focus more of its resources on the development and operation of launch vehicles and spacecraft for beyond LEO missions. If commercial crew or cargo were acquired in a typical cost-plus procurement manner, the cost would likely be higher than the current program. This new approach is providing cost avoidance.

Commercial Crew Development Program

12. Under the new agreement for a limited number of commercial partners under Space Act Agreements,

a. How will NASA ensure that its safety standards and human rating requirements will be met by the vehicles being developed?

A: NASA cannot impose requirements or standards on commercial companies via Space Act Agreements. However, NASA can terminate a Space Act Agreement if it determines that a commercial company's planned performance of an activity under that Agreement presents an unacceptable risk to human life. A clause to this effect is included in the CCiCap Space Act Agreements (SAAs).

In the case of the future Commercial Crew contracts for missions to the ISS, separate from the CCiCap activities, crew safety standards and human rating requirements will be applied and verified via FAR-based certification contracts. Thus, providers who wish to provide ISS crew transportation services in the future are incentivized to take NASA's human rating standards into account as they develop their vehicles.

b. What is NASA's authority to oversee crew safety under NASA's use of Space Act Agreements (SAAs)?

A: Please see response to #12a, above.

c. Please explain how NASA can ensure crew safety without contractual requirements.

A: Please see the response to 12a. Furthermore, NASA intends to use FAR-based contracts for system certification and for flights involving NASA crew, so NASA's requirements and standards will be imposed.

d. Who within NASA will certify that the commercial crew launches are "go for launch"?

A: For commercial crew launches, the commercial company, in coordination with the FAA, will be responsible for determining that they are "go for launch." NASA will not be certifying such flights for launch. NASA crew flights will only be performed under contracts, not Space Act agreements. The contracts will include terms to ensure crew safety. NASA intends that the FAA will license those flights for public safety.

NASA has not yet determined the details of how the flight readiness and mission management processes will be performed. At a minimum, NASA will have responsibility to certify that the NASA crew members are "go for flight." Furthermore, NASA will be responsible for verifying that a commercial company's transportation system fully meets NASA's human rating requirements prior to any launch involving NASA crew.

13. Are you considering the use of additional activities to ensure these vehicles can be certified for operational use, and to avoid the possibility of additional time and money being needed to bring them into compliance after this current development phase is finished?

A: Yes, NASA is developing a comprehensive strategy for certifying commercial crew transportation systems to NASA requirements, which will include methods of mitigating the risks that companies' designs will require costly modifications down the road to receive operational certification. NASA communicated this strategy to Congress before the CCiCap agreements were awarded.

14. The track record for Commercial Cargo development is poor regarding proposed vs. actual schedules. For example, SpaceX's original Demo 1 flight date was in September, 2008, but the actual flight was in December 2010; SpaceX's original Demo 2 flight date- was June 2009, and as we all know now they flew just last month; and finally Orbital's original Demo 1 flight date was in December 2010, but

the Current Plan is later this year. And Commercial Cargo is much simpler than Commercial Crew. What is your level of confidence in the Commercial Crew offerors making the promised readiness dates?

A: NASA is confident that if Congress funds the program to the level requested in the FY 2013 President's Budget that commercial crew transportation will be available by the end of calendar year 2017. The commercial participants have stated that they could make services available before 2017.

15. NASA has said that both commercial crew and exploration launches will use the same safety and human rating requirements, in particular "emergency egress" among those that will drive significant costs. Were these particular (and overall) requirements used and accounted for in all cost analyses to date?

A: Yes, NASA's cost estimates incorporate certification costs associated with meeting NASA's crew transportation certification requirements. NASA's understanding of these costs continues to mature as better data becomes available.

16. Is it true that the requirements for emergency crew return would preclude any vehicle from delivering crew members to the space station and then departing for a secondary destination?

A: NASA's requirements for ISS Crew transportation services, which are reference for CCiCap and will be mandated on future commercial crew contracts, include a capability for the CTS to remain docked to the ISS for up to 210 days to provide assured crew return for four NASA crew members. The ISS requires continuous presence of crew return spacecraft. However, these requirements do not preclude a vehicle from delivering crew members to the ISS and then departing, as long as there were sufficient crew return spacecraft at the ISS to enable full crew return.

INKSNA –Iran, North Korea and Syria Non-proliferation Act

17. Can you tell us the key reasons why the exception in the Iran, North Korea, Syria Non-Proliferation Act should be extended to enable us to purchase Russian goods and services for spaceflight?

A: Without further modification, INKSNA would have severely limited the U.S. from sustaining and fully utilizing the ISS and from pursuing a robust human exploration strategy that includes Russian capabilities. The Congress provided NASA with relief from INKSNA in the recently passed Space Exploration Sustainability Act.

18. What are the risks to the International Space Station if the ISS INKSNA exception is not extended?

A: See answer to question 17 above.

19. NASA has testified that INKSNA waiver language is needed whether we continue to buy Soyuz seats or not. Do you know what the current plan and status is for bringing proposed INKSNA language to the Congress from the Administration?

A: NASA is very grateful that Congress has passed H. R. 6586, the Space Exploration Sustainability Act, which extends the INKSNA exemption by 4 years and removes restrictions on non-ISS, human space flight-related activities. The relief provided in this legislation meets the Agency's need, and was the product of very hard work in both the House and the Senate, for which NASA is profoundly thankful.

ITAR Reform

20. There appears to be some movement recently in discussions regarding the ITAR reform process. Do you know if there is a plan for bringing a package of reforms to the Congress that would allow our aerospace industry to be truly competitive in the world market?

A: NASA has been supporting the Administration's efforts to reform the U.S. export control program and to revise the export control lists. Thus far, the Departments of State and Commerce have published proposed rules for nine of 19 categories of the United States Munitions List (USML) administered by the State Department. The State Department-proposed rules set forth what would remain in a given USML category, while the companion Commerce Department-proposed rules map out what would be moved from the USML. The Departments of Commerce, Defense, and State can provide more information on this effort.

Senator John Boozman
Senate Committee on Commerce, Science, and Transportation
Hearing on Risks, Opportunities, and Oversight of Commercial Space"
June 20, 2012
Questions for the Record

Bill Gerstenmaier, NASA

1. **NASA's budget documents indicate that in the transition from the Space Act Agreement phase to a certification phase, NASA will have to "accommodate redesign as necessary to ensure compliance with agency requirements."**

    a. **What is NASA doing to minimize the need to significantly redesign commercial partners' crew systems to ensure they meet agency requirements?**

A: NASA baselined and released the future certification requirements for industry to begin using as reference to mature their designs. All partners have access to the requirements and standards NASA will use for the future contracts for ISS.

For commercial crew services, crew safety standards and human rating requirements will be applied and verified via FAR-based certification contracts. Thus, providers who wish to provide ISS crew transportation services in the future are incentivized to take NASA's requirements into account as they develop their vehicles reducing the likelihood of significant redesign.

    b. **Does NASA have an estimate as to how much it might cost to ensure compliance?**

A: Please see response to #1a, above. Costs associated with redesign due to non-compliance will be partner-specific and NASA's understanding of these costs continues to mature as better data becomes available.

    c. **Do the savings presented by using a Space Act Agreement outweigh the lack of insight and oversight provided by a Space Act Agreement?**

A: Collaboration with industry in the early stages via Space Act Agreements allowed the Government and industry to mutually leverage each others' investments. As the program moves further into the development phase, NASA plans to use a Federal Acquisition Regulation (FAR)-based contract for certification of commercial systems prior to flying crew on these systems. The Agency intends to structure the certification effort to permit the Agency to fully evaluate the proposed systems and accommodate any necessary redesign to ensure compliance with NASA safety, performance, and mission success requirements. The provider(s) awarded a certification contract will not only be required to meet the NASA requirements in order to fly NASA personnel, but they will also have to show verified compliance of how the design and hardware will meet these requirements. The use of Space Act Agreements to support commercial development does not change the need to fully review and certify any system selected to transport NASA crew. NASA believes the combination of both FAR-based contracts and SAAs throughout various elements of the programs strikes an appropriate balance of cost effectiveness and insight and oversight.

d. **Is NASA comfortable that the level of insight and oversight during this critical phase of development is sufficient to provide the government with sufficient information to eventually certify a vehicle and ensure obtaining the best price possible when buying commercial crew services?**

A: Please see response to #1c, above, regarding vehicle certification. NASA has made awards to three companies in the latest phase of SAAs (CCiCap). The Agency believes the competitive environment provides strong incentive for the companies to align with NASA's certification requirements in order to remain competitive in the future certification and services phases. Having multiple companies competing against each other will help ensure the best price possible for the Government and will help enable voluntary adherence to safety requirements.

2. **Recently, the FAA and NASA signed an agreement to coordinate standards for commercial space travel of government and non-government astronauts to and from low-Earth orbit and the ISS. Can you please describe this agreement and responsibilities from the NASA point of view? Can you assure me that NASA will retain the ability to ensure that commercial crew carriers meet the same safety requirements that our other human spacecraft meet?**

A: The nature of the Federal Aviation Administration's (FAA) involvement in NASA's commercial crew activities will vary through the development and operation of each potential flight system. NASA will establish initial certification and operations requirements for the services it wishes to acquire from commercial providers and impose its requirements by contract. NASA will partner with the FAA to advance both public safety and protection of crews and spaceflight participants for the NASA-sponsored missions. NASA and the FAA will work towards minimizing the duplication of requirements and developing a streamlined process.

This will be accomplished by clearly defining roles and responsibilities of each Agency, sharing relevant data, and jointly performing assessments to enable the commercial partner to be successful in support of NASA-sponsored missions and non-NASA commercial human spaceflight missions. In support of this, NASA and the FAA recently signed a Memorandum of Understanding (MOU) to support the transition to commercial transport of government and non-government persons to LEO in a manner that avoids conflicting requirements and multiple sets of standards. In developing these standards, the parties will exchange knowledge and best practices in the various disciplines of space flight, including safety.

3. **As you know, the long term goal of U.S. human space flight and exploration efforts is to expand permanent human presence beyond low-Earth orbit. But in order to do so, the United States must have assured access to the ISS for our astronauts and must design and build the new rockets to take us beyond low-Earth orbit: the Space Launch System and Orion crew capsule. The government must work in cooperation with the U.S. commercial sector in order to accomplish these objectives. Space, however, is an unforgiving environment, resulting in unusually hazardous risks, which can be a deterrent to commercial sector participation. It has been the U.S. policy since at least 1958 to provide its private sector contractors some assurance that engaging with the government in such unusually hazardous activities will not put their business at total risk should there be a catastrophic failure resulting in damages to third parties through use of an indemnification regime.**

   The Commercial Space Launch Act authorizes the FAA to license launch and reentry activities other than those activities the Government carries out for the Government. Who has the responsibility to determine when activities under NASA contracts are Government activities carried out for the Government?

   A: NASA has the responsibility to determine when activities under NASA contracts are Government activities carried out for the Government. NASA decides whether any particular launch is a government launch (where it substantially directs or controls the launch) or a commercial launch depending on the needs of the program. As part of the program formulation and acquisition processes, the roles for NASA and the contractor, including the roles related to the conduct of launch are established based on the best interests of the Government and the public, consistent with law and policy. As an example of this decision-making process, NASA recently determined that all launches supporting ISS crew transportation services will be commercial, thus licensed by the FAA. NASA and FAA entered into an MOU for Achievement of Mutual Goals in Human Space Transportation on June 4, 2012, to among other things, work together to reach a common understanding and approach for meeting that objective.

   As noted, the Commercial Space Launch Act, provides the Secretary of Transportation (acting by delegation through the FAA Office of Commercial Space Transportation) authority to license and permit commercial launches and reentries. The Secretary's authority does not apply to "(1) a launch, reentry, operation of a launch vehicle or reentry vehicle, operation of a launch site or reentry site, or other space activity the Government carries out for the Government . . ." 51 U.S.C. 50919(g). Therefore, launch and reentry activities that are not commercial (carried out by NASA for the Government) are not licensed by the FAA.

   NASA has the responsibility as part of its program formulation and acquisition processes to determine whether activities under NASA contracts retain for the Government NASA direction and control, and are thus Government activities carried out for the Government or are commercial launches.

4. NASA had used authority under Public Law 85-804 to provide third-party indemnification assurances for Shuttle launches. What authority does NASA intend to use for SLS and Orion launches? Or for future science payload launches under the Launch Services Program, for example?

A: NASA was able to provide indemnification to its Shuttle contractors under P.L. 85-804 (50 U.S.C. §§ 1431-1435) for claims for unusually hazardous risks because NASA was able to make the determination that doing so facilitated the national defense. Recall that the DoD was a user of the Shuttle.

Similarly, in order for NASA to be able to utilize the authority of P.L 85-804 for other launch programs such as NASA Launch Services (NLS), Space Launch System (SLS), and the Multipurpose Crew Vehicle, (MPCV or Orion), the Agency would have to demonstrate a nexus between the commercial contract requirements and facilitating the national defense. Otherwise, NASA has no authority to provide P.L. 85-804 indemnification to its contractors even for activities that are unusually hazardous.

Under the NLS contract, NASA utilizes its meritorious tort claim authority (51 U.S.C. § 20113(m)). It is not an indemnification authority. It covers third-party claims against the contractor arising from performance of the contract, but NASA may only pay claims up to $25,000 (above any claims covered by insurance). Claims in excess of $25,000 would be forwarded by NASA to the Treasury for consideration of payment from the judgment fund under 31 U.S.C. §1304. NASA may certify such claims to facilitate payment from the judgment fund.

At this time, NASA has not determined whether any indemnification protection would be available to the SLS and Orion contractors. However, the Agency's meritorious tort claim authority may be provided to them. Likewise, future science payloads under the NLS contact may be protected through the Agency's meritorious tort claim authority, as is currently available under NASA's NLS contract with its launch service providers.

5. In the past, budget estimates were requested for the life cycle costs to develop the commercial crew vehicle. Can you share this information now, based on the risk/cost/safety trades NASA is currently making? What are the key risks for the safety of commercial crew?

A: NASA has recently collected detailed technical information from our CCiCAP partners for projected cost/schedule requirement to complete development and achieve a crewed flight demonstration. NASA will use this information as input to cost and schedule models to support an independent cost assessment, develop a more rigorous project plan, and inform updates of NASA's budget estimates for the certification phase 2 as part of the FY 2014 budget request. Each partner concept has its own unique risks and they are tracked by the companies, with NASA insight.

6. While U.S. cooperative programs with Russia were expanding in the 1990's, including Russia joining the space station international partnership in 1993, it also

became clear that Russia was a source of sensitive technology to Iran. The Iran Nonproliferation Act of 2000 was enacted to help stop foreign transfers to Iran of weapons of mass destruction, missile technology, and advanced conventional weapons technology, particularly from Russia.

Among other things, that Act banned cash or "in kind" payments by any agency of the U.S. Government to Russian Government agencies or to any entity under their jurisdiction or control for work on the International Space Station or for obtaining goods and services relating to human spaceflight. This provision has raised difficulties regarding U.S. access to the International Space Station. When the President in 2004 announced that the Space Shuttle would be retired in 2010, the Russian *Soyuz* became the only vehicle available after that date to transport astronauts to and from the ISS. In 2005 Congress amended INA to exempt *Soyuz* flights to the ISS from the ban through 2011 and in 2008 the exception was further extended through June 30, 2016.

Is a further extension necessary? If so, why?

A: Without further modification, INKSNA would have severely limited the U.S. from sustaining and fully utilizing the ISS and from pursuing a robust human exploration strategy that includes Russian capabilities. The Congress provided NASA with relief from INKSNA in the recently passed Space Exploration Sustainability Act.

Senate Committee on Commerce, Science, & Transportation
Full Committee Hearing
"Utilization of the International Space Station"
Wednesday, July 25, 2012
Senator Bill Nelson

Maximizing ISS Utilization

Now that construction of the space station is complete, the goal has shifted to getting the most out of the station's research capacity.

1. What metrics would tell us we are doing a good job maximizing productivity of the station?

ANSWER: NASA tracks many metrics that show different dimensions of the productivity of the International Space Station (ISS). Monthly productivity metrics are collected on such metrics as numbers of investigations and investigators, science disciplines accommodated, facility occupancy, dedicated research crewtime, numbers of countries involved, numbers of students reached, and numbers of scientific publications. For example, the number of scientists participating in ISS research has grown to over 400 on every Expedition and the number of countries involved in ISS research and education activities during an Expedition is typically over 30. The ISS is a growing resource for the science community, serving such diverse science disciplines as biotechnology and biology, human research, physical science, Earth and space science, technology demonstrations and education. Over 31 million students in the United States have participated in demonstrations performed by crewmembers aboard the ISS over its lifetime. The ISS is stimulating young people to ask questions and pursue knowledge. With a careful review and adjustment of crew commitments, the crew time for research has consistently grown, and now typically exceeds the minimum requirement of 35 hours per week.

Senate Committee on Commerce, Science, & Transportation
Full Committee Hearing
"Utilization of the International Space Station"
Wednesday, July 25, 2012
Senator Amy Klobuchar

1. Mr. Gerstenmaier, we were saddened to hear on Monday of the loss of the first American female astronaut, Sally Ride, to cancer. She will be remembered as a courageous pioneer who inspired girls everywhere to be excited about science. 25 years later in 2008, Minnesota native Dr. Karen Nyberg became the 50th woman to enter outer space and is scheduled to return to the ISS in May of next year. Despite such advances, entrance among girls and young women into fields such as physics and engineering continues to be disproportionately lower than men.

- 29 years after Sally Ride's first trailblazing mission, what can NASA do to inspire more women to enter the STEM fields, which are so critical to America's continued prosperity?

ANSWER: We were equally saddened by the loss of Dr. Ride. She was an American hero, and a role model for generations of girls. NASA has a longstanding education partnership with Sally Ride Science, and they manage the EarthKam activity for the Agency, which allows middle school students to study the Earth using a camera installed on the International Space Station. We also agree with you that it is important to continue working to increase the number of women entering the STEM fields. NASA is taking advantage of its unique resources, including people, assets, and facilities to further inspire women and girls.

Recent data released this year by the Girl Scouts Research Institute shows that girls are already interested in math and science. However, they are also interested in numerous other fields of study, which compete with STEM fields when choosing majors in college and careers thereafter. A major finding of the study showed that female mentors in STEM fields and exposure to those fields is important when girls choose their future paths. As such, NASA is committed to providing mentors and numerous outreach opportunities to young women and girls. The following are only a small representation of the varied opportunities NASA offers across the nation, in hopes of inspiring the next generation of young women and girls to enter and remain in science, technology, engineering, and math careers.

The referenced Girl Scouts Research Institute Report can be found here:
http://www.girlscouts.org/research/publications/stem/generation_stem_what_girls_say.asp

NASA facilitates volunteer opportunities for our STEM employees for the mentoring of young girls through the following programs:

- Aspire 2 Inspire (http://women.nasa.gov/a2i)
- NASA G.I.R.L.S. (http://women.nasa.gov/nasa-g-i-r-l-s)
- NASA WISH (http://women.nasa.gov/wish)
- NASA SISTER (http://women.nasa.gov/outreach-programs)

NASA is committed to allowing our employees to perform outreach activities as their schedules permit. Many of these outreach activities focus on underrepresented groups in STEM. For example, through NASA's Teaching From Space program, the program targeted female middle school students with the development of a "Women in STEM" video. In collaboration with NASA Public Affairs Office, Teaching From Space used the STS-131 mission and the role of crewmember Dottie Metcalf-Lindenburger, a former classroom teacher turned astronaut, to showcase NASA career opportunities for females (http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Women_at_NASA.html). NASA also maintains a Speaker's Bureau to provide speakers for public inquiries, often responding to requests to speak to women and girls.

NASA is committed to communicating the message that STEM is for everyone using role models young women and girls have in areas outside of STEM fields. One such example is collaboration with award-winning recording artist Mary J Blige to encourage young women to pursue exciting experiences and career choices through studying science, technology, engineering and mathematics. A public service announcement featuring Associate Administrator for Education and veteran NASA space shuttle astronaut Leland Melvin and Blige can be viewed here: http://www.nasa.gov/offices/education/programs/national/summer/media/blige_melvin.html

NASA is committed to creating opportunities for students in STEM programs at the nation's universities. The Motivating Undergraduates in Science and Technology (MUST) project awards scholarships and internships to undergraduates pursuing degrees in STEM fields. In FY 2010, the MUST project hosted 100 students, of whom 55 percent were women and 27 percent of the scholars self reported being the first in their family to attend college.

Senate Committee on Commerce, Science, & Transportation
Full Committee Hearing
"Utilization of the International Space Station"
Wednesday, July 25, 2012
Senator Mark Warner

1. Mr. Gerstenmaier, with the retirement of the Space Shuttle, the United States is in need of finding a means to transport cargo and experiments to and from the International Space Station (ISS). In order to serve this need, the United States will surely be looking at possible launch sites to serve the ISS. It is my understanding that the flight trajectory from the NASA Wallops Flight Center to the ISS has some advantages, and could be viewed as more favorable and efficient than other sites located around the U.S.
    a. What do you see as the future of NASA Wallops in terms of its relationship with the ISS?

ANSWER: NASA currently has two companies under contract to provide resupply services to the ISS. One of the two companies, Orbital Sciences Corporation, selected Wallops Flight Facility (WFF) as its launch location for ten scheduled missions (two development flights and eight cargo flights). By virtue of Orbital's selection, WFF will be providing integration and testing services and launch operations support for 2-3 launches annually for the duration of Orbital's existing contract, and potentially longer.

b. What benefits does NASA Wallops have in serving the ISS?

ANSWER: Due to the inclined orbit of ISS, only two established U.S. launch sites are suitable to support resupply missions, the USAF's Eastern Range in Florida, and NASA's Wallops Flight Facility (WFF) in Virginia. The geometry of the ISS orbit results in a slight technical advantage for launches conducted from WFF, allowing additional mass to be lifted to the same orbit using a comparable rocket. In addition, as a NASA facility, WFF offers the opportunity to leverage already-funded NASA launch range and institutional capabilities, resulting in cost savings. The current arrangement of two contractors operating from different launch sites also provides NASA with increased flexibility and reliability, assuring that critical resupply needs are not interrupted due to launch range schedule conflicts, a launch vehicle fleet technical issue, or facility damage resulting from severe weather.

2. Mr. Gerstenmaier, as we have previously discussed, there is a lot of promise in pharmaceutical research in the microgravity environment of low-Earth orbit in which the International Space Station operates.

a. Can you provide a status update on your efforts for pharmaceutical research in micro-gravitational environments?

ANSWER: The best known of the recent pharmaceutical projects using the ISS -- the vaccine development work of Astrogenetix -- has completed flight experiments needed to identify mutant bacterial strains the company believes will enable the development of effective vaccines against Salmonella and methicillin-resistant Staphylococcus aureus infection. Astrogenetix is seeking venture funding to support clinical trials and further development.

Future ISS-based research in pharmaceutical development will be conducted through the organization selected in 2011 to manage non-NASA use of the ISS National Laboratory, the Center for the Advancement of Science in Space (CASIS). The initial CASIS Board of Directors includes a cross-section of leaders from several scientific disciplines and pharmaceuticals research. CASIS is currently developing lines of research identified by a panel of biomedical scientist from a survey of prior space research as holding significant promise for commercial participation, and the 7-member board recently named will select an additional 8 members with the intent of including prominent individuals from various industries.

b. Are pharmaceutical companies interested in partnering on this initiative?

ANSWER: CASIS, through the science team assembled to steer the development of its pharmaceutical research plans, has conducted surveys to identify corporate interest in new research thrusts. There is an interest and recognition on the part of industry of the value of pharmaceutical research in the microgravitational environment, and the level of corporate interest, and corporate willingness to invest in space research, is a major factor in selecting new research projects. It does take time, however, to translate that interest into investment.

c. What obstacles are you encountering in seeing that this research gets done?

ANSWER: Some research projects involve new operational challenges. The upcoming experiments with mice on the ISS, for example, will be the first experiments on the ISS with rodents, and the mice will be flying for the first time in a SpaceX Dragon capsule. Another obstacle is the increasingly cautious investment climate for commercial research and development, including pharmaceutical research. The pharmaceutical industry is scaling back its expenditures in basic research, and focusing on more mature concepts. They're looking for comprehensive evidence to justify investments. That is a challenge in an exploratory field like space biology.

Don Pettit
NASA JSC
Houston, TX

Senate Committee on Commerce, Science, & Transportation
Full Committee Hearing
"Utilization of the International Space Station"
Wednesday, July 25, 2012
Senator Bill Nelson

Maximizing ISS Utilization

1. Now that construction of the space station is complete, the goal has shifted to getting the most out of the station's research capacity.

- What metrics would tell us we are doing a good job maximizing productivity of the station?

As Mr. Gerstenmaier reports in his answer to Senator Nelson's question, NASA tracks many metrics that show different dimensions of the productivity of the International Space Station (ISS). Monthly productivity metrics are collected on such metrics as numbers of investigations and investigators, science disciplines accommodated, facility occupancy, dedicated research crew time, numbers of countries involved, numbers of students reached, and numbers of scientific publications.

From my perspective as an ISS astronaut, I would offer the following for consideration on utilization metrics for the ISS, which could be the basis for future improvements in monitoring and defining ISS progress.

The International Space Station is a diverse laboratory in a harsh frontier environment where defining a single metric for success is difficult if not counterproductive. There are three distinct categories I believe are worthy of a metric to evaluate progress and each should be considered when it is appropriate to do so. One is for a mission covering a particular six person crew, another is for an annual review for the Space Station as a whole, and a third is for internal metrics developed as administrative/operational tools to aide in the allocation of crew time and resources.

For a particular mission covering a six month period where nine individuals rotate to maintain a six person crew, the metrics should be based on the following: crew health, vehicle health, and completing the required work. Crew health covers the safety and well being of the crew, including following prescribed countermeasures and maintaining professional positive attitudes towards crewmates and mission control. Vehicle health is a divided responsibility between mission control and crew. Repair and maintenance of systems and research apparatus is essential to sustaining an operating vehicle in a harsh environment where logistic for spare parts and limited crew time can complicate matters. Vigilance by both crew and mission control is required to extend the useable life for vehicle thus creating an efficient safe environment where the mission work can be completed. The crew is part of a large international team that includes their crewmates as well as the control centers scattered over many countries. Being able to work together as a team is essential to mission success. Completing the required work is self-explanatory and includes completing the research objectives defined.

An annual review for the Space Station as a whole includes research accomplishments as well as the overall state of the vehicle health. Accomplishments include both advances in scientific research as well as engineering research (engineering research includes prototype spacecraft systems operating in space using Space Station as a test platform). This evaluation should use the time-tested practice of external review for proposed projects and peer review when the final papers are published (this is currently being done for research on Space Station). This review process will ensure high quality ideas, projects, and final technical publications are maintained. The overall state of the vehicle should be reviewed on an annual basis to track factors affecting the long-term health and lifetime of the stack.

Universities and National Laboratories (such as Los Alamos National Laboratory where I worked for 12 years) rely on similar peer review to maintain high quality research and use peer reviewed publications, citation indexes (how often a paper is cited by others working in the field), and patents as a part of the evaluation metric.

It is essential to realize that it takes years to bring research to fruition whether at universities, national laboratories, or now, Space Station. Patience must be exercised when evaluating the research returns on a new endeavor (Space Station was just completed and placed in a full operational state last year).

Internal metrics developed as administrative/operational tools are useful to aide in the allocation of crew time and resources. Such metrics, when taken out of context, may seem ill-fit; however, these were never intended as a means to evaluate over all Space Station performance. For example, consider maintenance and repair of a complex vehicle in a harsh environment (this applies to sail boats as well as to Space Station). If left unchecked, maintenance and repair could expand to take all available crew time. To ensure that a significant fraction will be available for mission research, an internal metric has been set to reserve about 1/3 of mission related crew work hours for research. This metric, as an internal administrative tool, has caused critical review of all maintenance procedures, resulting in a workable compromise where both research and maintenance are completed. The practice of using such internal metrics needs to be understood and kept separate from the metrics for evaluating Space Station.

In closing, I believe there are three useful types of metrics for evaluating Space Station: 1) for the mission metrics of a particular 6 person crew, 2) as an annual review of Space Station research and vehicle health, and 3) internal metrics used as administrative tools for allocation of resources and crew time. All three of these have a different emphasis and are each in turn useful when applied to their particular situation.

From: Campbell, Michelle (HQ-VA030)
To: Webb-Queen, Sonya (HQ-VA020)
Subject: FW: 7/25 ISS Hearing Corrections and QFRs
Date: Monday, August 06, 2012 6:07:03 PM
Attachments: 37527.doc
37527.pdf
120725 Gerstenmaier QFRs.docx
120725 Pettit QFRs.docx

From: <Ruffin>, "Andrew (Commerce)" <Andrew_Ruffin@commerce.senate.gov>
To: "Cremins, Tom (HQ-VA030)" <tom.cremins-1@nasa.gov>, "Whitson, Peggy A. (JSC-CB111)" <peggy.a.whitson@nasa.gov>
Cc: "Irving, Richard R. (HQ-VA030)" <richard.r.irving@nasa.gov>, Michelle Campbell <michelle.campbell@nasa.gov>, Ann_Zulkosky <Ann_Zulkosky@commerce.senate.gov>
Subject: 7/25 ISS Hearing Corrections and QFRs

Tom and Peggy,
Thanks to all for your hard work preparing for and testifying at our July 25 hearing, "The International Space Station: A Platform for Research, Collaboration, and Discovery." Attached please find questions for the record from Senators Nelson, Klobuchar, and Warner, as well as PDF and Word copies of the unofficial hearing transcript. While I usually collect and send QFRs from both sides of the Committee, please expect a separate email from the minority side in the near future.
Transcript Corrections: Please review the testimony and answers for accuracy, and make any necessary typographical or grammatical corrections, *provided they do not change the context of your original testimony*. Revisions should be made electronically (using tracked changes in Word) OR printed, marked by hand in contrasting color, and sent electronically once scanned (using the PDF copy).

Questions for the Record: Please submit a single document containing the posed questions followed by your answers for insertion in the printed hearing record. I have included the QFRs for both Mr. Gerstenmaier and Dr. Pettit.

Please submit only the pages with any corrections electronically and question responses to Andrew_Ruffin@commerce.senate.gov and docs@commerce.senate.gov no later than **Monday, August 27, 2012**. Should the Committee not receive your response within this time frame or if I am not notified of any delay, the Committee reserves the right to print the transcript as provided. If you feel you may not make the deadline or you have any other questions, please contact me in advance of the deadline.
Sincerely,
Andrew Ruffin
U.S. Senate Committee on Commerce, Science, and Transportation
Subcommittee on Science and Space

Senate Committee on Commerce, Science, & Transportation
Full Committee Hearing
"Utilization of the International Space Station"
Wednesday, July 25, 2012
Senator Bill Nelson

Maximizing ISS Utilization

Now that construction of the space station is complete, the goal has shifted to getting the most out of the station's research capacity.

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Senate Committee on Commerce, Science, & Transportation
Full Committee Hearing
"Utilization of the International Space Station"
Wednesday, July 25, 2012
Senator Amy Klobuchar

Mr. Gerstenmaier, we were saddened to hear on Monday of the loss of the first American female astronaut, Sally Ride, to cancer. She will be remembered as a courageous pioneer who inspired girls everywhere to be excited about science. 25 years later in 2008, Minnesota native Dr. Karen Nyberg became the 50th woman to enter outer space and is scheduled to return to the ISS in May of next year. Despite such advances, entrance among girls and young women into fields such as physics and engineering continues to be disproportionately lower than men.

- **29 years after Sally Ride's first trailblazing mission, what can NASA do to inspire more women to enter the STEM fields which are so critical to America's continued prosperity?**

Senate Committee on Commerce, Science, & Transportation
Full Committee Hearing
"Utilization of the International Space Station"
Wednesday, July 25, 2012
Senator Mark Warner

1. Mr. Gerstenmaier, with the retirement of the Space Shuttle, the United States is in need of finding a means to transport cargo and experiments to and from the International Space Station (ISS). In order to serve this need, the United States will surely be looking at possible launch sites to serve the ISS. It is my understanding that the flight trajectory from the NASA Wallops Flight Center to the ISS has some advantages, and could be viewed as more favorable and efficient than other sites located around the U.S.
    a. What do you see as the future of NASA Wallops in terms of its relationship with the ISS?
    b. What benefits does NASA Wallops have in serving the ISS?

2. Mr. Gerstenmaier, as we have previously discussed, there is a lot of promise in pharmaceutical research in the microgravity environment of low-Earth orbit in which the International Space Station operates.
    a. Can you provide a status update on your efforts for pharmaceutical research in micro-gravitational environments?
    b. Are pharmaceutical companies interested in partnering on this initiative?
    c. What obstacles are you encountering in seeing that this research gets done?

Questions for the Record
Chairman Steven Palazzo
Spurring Economic Growth and Competitiveness Through NASA Derived Technologies
Space and Aeronautics Subcommittee Hearing
July 12, 2012

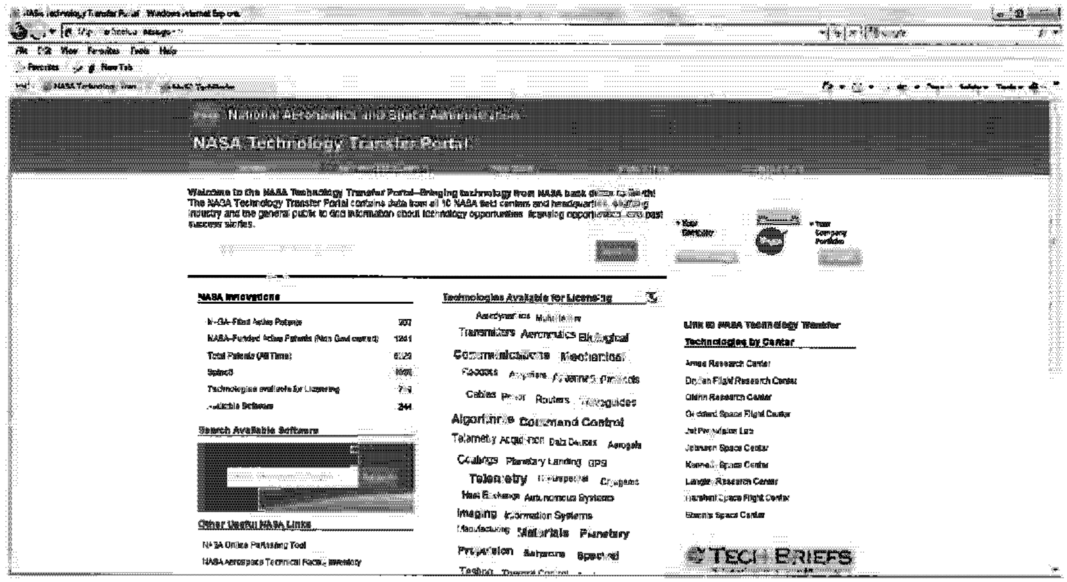
1. Your testimony states that your office is currently reviewing NASA technology transfer policies and will be revising them in the coming year. When will you be able to provide us with the details of those changes?

   ANSWER: The Agency is revising its technology transfer policies to better match current best practices, and to address commercialization planning. The new policy will provide a streamlined, broad, flexible approach to core technology transfer activities, with an emphasis on coordination of technology transfer offices with programs and projects. This increased coordination will assist NASA in best understanding the value of identified technological assets. Revised policies will go into effect in 2013, at which time NASA will pursue activities to increase internal and external awareness of these policies. Additionally, NASA has, in response to a presidential memorandum, developed a plan for accelerating technology transfer activities. This plan has been approved and will be posted online at: http://www.nasa.gov/offices/oct/tech_transfer/index.html.

2. Your testimony mentions a series of internal initiatives aimed at increasing NASA personnel's awareness of the agency's technology transfer policy as a response to the IG's findings. Can you please explain to us what these initiatives are and how will you measure their effectiveness?

   ANSWER: The Office of the Chief Technologist will update the Agency technology transfer policy to reflect an emphasis on those practices that best lead to commercialization while still meeting multiple statutory requirements. Currently a NASA team is reviewing industry best practices, surveying NASA staff, and working with various programs within the Agency to draft a new technology transfer policy document that will be implemented in 2013. OCT will lead and implement an awareness campaign on new technology reporting, to include development of a formal training module to be made available in NASA's e-Learning tool.

   In addition, NASA has already created a publicly available website which tracks key Agency metrics including patents, Spinoffs, technologies available for licensing, and available software. This website, http://technology.nasa.gov/, serves as a high level dashboard to provide real-time access to technology transfer metrics for the public, NASA Administrator and senior managers. NASA will develop metrics for tracking the success of these initiatives and will report them on a regular basis to senior management at Agency-level councils. The measurements shown on the dashboard will be used to track effectiveness and bring awareness to progress throughout the year.


National Aeronautics and Space Administration
NASA Technology Transfer Portal
NASA Innovations
Technologies Available for Licensing
Search Available Software
Other Useful NASA Links
Link to NASA Technology Transfer Technologies by Center
Ames Research Center
Glenn Research Center
Johnson Space Center
Langley Research Center
Stennis Space Center
TECH BRIEFS

Questions for the Record
Representative Dana Rohrabacher
Spurring Economic Growth and Competitiveness Through NASA Derived Technologies
Space and Aeronautics Subcommittee Hearing
July 12, 2012

1. Does NASA receive compensation when it research investment is broadly used as the basis of a new product owned by a private company?

   ANSWER: NASA receives monetary compensation in the form of licensing fees and royalties when it licenses technology to a private company. NASA licenses technology when a patent application on the technology has been filed and the patent application names NASA as a sole or joint owner of the technology.

   Most of NASA's technology, however, is not covered by a patent or patent application. Such technology is available for private use without compensation to NASA. Even when NASA does not receive compensation, it advances NASA's mission when NASA technology is used to benefit the general public and help support U.S. industry.

2. Is there payback or benefits for NASA if its technology becomes widely used throughout the world? What about licensing fees?

   ANSWER: See Answer 1 above. Additionally, if NASA is named as a sole or joint owner on non-U.S. patent applications, NASA has the authority to license the technology in the corresponding non-U.S. country and receive licensing fees and royalties. Most of NASA's licenses, however, are limited to the U.S.

3. Who owns the technology, patent, or intellectual property rights if a company commercializes a product from NASA R&D investment?

   ANSWER: If a commercial company makes improvements to NASA technology to support commercialization, the commercial company owns those improvements. NASA retains its rights (if any) in the base technology arising from the original R&D investment.

4. Is NASA planning to pursue and demonstrating green propellant in space? If so, what propellants and specify the timeline?

   ANSWER: Following a solicitation and peer-review selection process, NASA chose the Green Propellant Infusion Mission proposal and a team lead by Ball Aerospace & Technologies of Boulder, Colorado, and co-investigators from the Aerojet Corporation in Redmond, Washington, the U.S. Air Force Research Laboratory at the Wright Patterson Air Force Base in Ohio, the U.S. Air Force Space and Missile Systems Center at the Kirkland Air Force Base in New Mexico, NASA's Glenn Research Center in Cleveland and NASA's Kennedy Space Center in Florida for a technology demonstration of a high performance "green" propellant alternative to the highly toxic fuel hydrazine.

This demonstration will bridge the gap between technology development and use of green propellant. The team will develop and fly a high performance green propellant (called AF-M315E/hydroxylammonium nitrate (HAN)-based propellant), demonstrating and characterizing in space the functionality of the integrated propulsion system. Such a demonstration will provide the aerospace community with a new system-level capability for future missions.

Questions for the Record
Ranking Member Jerry Costello
Spurring Economic Growth and Competitiveness Through NASA Derived
. Technologies
Space and Aeronautics Subcommittee Hearing
July 12, 2012

1. To what extent can the direct and indirect economic impacts of NASA investments be measured?

   ANSWER: Estimates of the direct and indirect economic impacts of NASA investments have ranged widely. Although recent developments in informational technologies have the potential to increase the precision of such economic assessments, improvements in the precision of these measurements are not expected to be forthcoming in the near-term. In the meantime, less precise, but nonetheless valuable assessments must suffice. There is evidence that 8 of the top 10 fastest growing industries in the United States from 1960-1990 were areas directly impacted by NASA R&D[1].

2. What has NASA learned over the years, as well as from other Federal R&D agencies, on how to successfully transfer technologies to the commercial sector, and how is NASA acting on those lessons learned?

   ANSWER: In a recent Inspector General audit of NASA's program, the IG found NASA personnel lacked awareness of the New Technology Reporting process and were not using NTRs to identify potential technology benefits: "Specifically, personnel we interviewed did not realize the transfer potential of some technological assets, and project managers did not develop and IPO personnel did not assist in the development of Technology Commercialization Plans (Commercialization Plans)...Consequently, NASA has missed opportunities to transfer technologies from its research and development efforts and to maximize partnerships that could provide additional resources, and industry and the public have not fully benefited from NASA-developed technologies."

   Through this finding, NASA learned the importance of keeping policy updated and providing regular training to technical staff to ensure awareness of the requirements and benefits of reporting new technology.

   NASA participates in a number of Technology Transfer communities of practice to ensure the agency is taking advantage of effective strategies and approaches developed both internally and within the federal community. NASA Centers host community of practice meetings on a twice-monthly basis to discuss challenges, best practices, and to leverage resources; additionally, NASA is an active participant in the Federal Laboratory Consortium at both the national and regional levels.

3. To what extent is commercialization of NASA technologies enhanced by higher funding levels for NASA? What priorities would you address with additional resources?

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[1] Department of Commerce "Engines of Growth: Manufacturing Industries in the U.S. Economy" 1995.

ANSWER: The rate of commercialization fluctuates due to a variety of factors including:

- rate of investment in technology development across the agency
- funding made available for technology transfer support

While NASA is engaged in many new initiatives to improve and streamline its technology transfer process, the first element in a robust technology transfer program is a rich portfolio of cutting edge technologies. Increased funding for NASA technology development would lead to additional technologies available for transfer and commercialization.

With additional funding for technology transfer, NASA would restore funding for several key functions that have been lost due to years of steady budget decline, including increasing the number of available patent attorneys and other core technology transfer functions. NASA would also increase the number of technologies it is able to assess per year, begin prototyping and providing bridge funding for technology development, and increase public outreach.

4. What performance metrics does NASA use to determine the effectiveness of its technology transfer and commercialization activities and individual partnerships, and what is the basis for those metrics?

ANSWER: NASA does not commercialize technologies. It may develop technologies and processes with commercial potential that are then commercialized by industry. It may create an environment that supports commercialization of its technologies by industry partners. The process of developing a commercial product, though, is inherently non-governmental. NASA, therefore, does not have commercialization metrics.

NASA conducts routine follow-up with industry partners to determine whether those companies have successfully commercialized its technologies. These are tracked and recorded in the Agency's annual *Spinoff* report, available online at http://spinoff.nasa.gov.

While NASA does not generate commercial products, it does strive to foster an environment from which its technologies can be transferred to industry and commercialized. To monitor and measure this environment, NASA uses standard governmental technology transfer metrics.

All Federal Agencies performing technology transfer are subject to the same performance metrics for technology transfer. The currently required metrics collected and reported by each agency as codified at 15 USC 3710 (f) are:
(A) an explanation of the agency's technology transfer program for the preceding fiscal year and the agency's plans for conducting its technology transfer function, including its plans for securing intellectual property rights in laboratory innovations with commercial promise and plans for managing its intellectual

property so as to advance the agency's mission and benefit the competitiveness of United States industry; and

(B) information on technology transfer activities for the preceding fiscal year, including—

(i) the number of patent applications filed;

(ii) the number of patents received;

(iii) the number of fully-executed licenses which received royalty income in the preceding fiscal year, categorized by whether they are exclusive, partially-exclusive, or non-exclusive, and the time elapsed from the date on which the license was requested by the licensee in writing to the date the license was executed;

(iv) the total earned royalty income including such statistical information as the total earned royalty income, of the top 1 percent, 5 percent, and 20 percent of the licenses, the range of royalty income, and the median, except where disclosure of such information would reveal the amount of royalty income associated with an individual license or licensee;

(v) what disposition was made of the income described in clause (iv);

(vi) the number of licenses terminated for cause; and

(vii) any other parameters or discussion that the agency deems relevant or unique to its practice of technology transfer.

In addition, agencies currently report information regarding the number of Cooperative Research and Development Agreements (CRADAs) conducted by the agency pursuant to 15 USC 3710a.

Along with other agencies, NASA reports these metrics to Department of Commerce, for the Federal Laboratory Technology Transfer Summary Report submitted to the President and the Congress. In addition, the National Center for Science and Engineering Statistics of the National Science Foundation (NSF) uses the data to support the semiannual Science and Engineering Indicators (SEI) report. NASA also makes this data available to the public through the Agency's Technology Transfer Portal: http://technology.nasa.gov

Additionally, NASA, in coordination with OMB, has identified technology transfer as one of the Agency's High Priority Goals and committed to increasing the numbers of new invention disclosures, software usage agreements, patents, and licenses NASA is able to produce per year. Additional details of this goal and NASA's progress toward meeting it will be available on www.performance.gov.

5. It is not widely known that Zephyr's BioHarnesses monitored miners' wellness during the Chilean mine accident. Mr. Russell's prepared statement indicates that Zephyr is sharing the data collected during those dramatic weeks with NASA. How will that data be useful to NASA and to human exploration specifically?

   ANSWER: The NASA and Zephyr Technology partnership under a Space Act Agreement was instrumental in the development of advanced physiological monitoring capabilities that could allow NASA to remotely monitor astronaut physiological responses during future deep space missions. From work under this partnership, Zephyr was better able to bring their enhanced and reliable Zephyr BioHarness product to the market place. In the case of the Chilean miner accident, this proved invaluable in helping the Chilean government to rescue the miners in good health.

During the Chilean miner rescue effort, miners used several of the current NASA health related countermeasures which are also used by astronauts on return to Earth from space, including a fluid loading protocol and wearing appropriate compression garments to maintain blood pressure. The Zephyr BioHarness allowed physiological measurements of the miners to assess their health during the long ascent through the rescue tunnel, a time that they were under great stress. The remote monitoring allowed real-time observation and allowed preparation for treatment at the surface if necessary. In addition to supporting the successful rescue effort, NASA was also interested in confirming that the medical protocols applied from spaceflight were indeed applicable and helpful in this particular medically stressful situation, and it corroborated clinical findings from NASA crewmembers.

As NASA's Human Exploration and Operations Directorate prepares for work by Astronauts in the extreme environment of space, NASA looks forward to potentially using the Zephyr BioHarness data from the Chilean miner rescue effort to verify and enhance R&D related to mitigating the health hazards associated with extreme and stressful environments. By working with and partnering with companies like Zephyr Technology, NASA is able to obtain necessary reliable medical data that is transmitted from the individual being monitored to some other distant site, and secondly to obtain medical risk assessment data so that NASA may make better decisions for supplying medical equipment, therapeutics, diagnostics and rehabilitation items for future long-duration space exploration missions.

The partnership between NASA and Zephyr Technology has enhanced the development of medical tools that can be used during space missions and significantly has also been proven to be effective and important here on Earth.

Questions for the Record
Congresswoman Donna Edwards
Spurring Economic Growth and Competitiveness Through NASA Derived Technologies
Space and Aeronautics Subcommittee Hearing
July 12, 2012

1. What is NASA doing to accelerate technology transfer and commercialization of its research, development, and technology consistent with the direction in the President's Memorandum on "Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses"? When can Congress expect a report documenting the agency's progress towards meeting the President's direction?

   ANSWER: In response to the Presidential Directive, NASA is in the process of developing a five-year plan to improve its technology transfer program activities. Key objectives in the draft plan include the following:

   - Revise Agency policies to ensure alignment with NASA's commitment to technology transfer best practices.
   - Build partnerships for technology development, transfer, and mutual benefit.
   - Engage the technology transfer process at all stages of technology development, ensuring that formal technology transfer is considered at the earliest phases of program and activity formulation and acquisition planning.
   - Increase the number of new technologies reported by NASA civil servants and contractors.
   - Develop and implement innovative methods for technology licensing.
   - Increase Agency use of Cooperative Research and Development Agreement (CRADA) authority[2] to accelerate licensing of resulting technologies.

   Each of these objectives is supported by a series of identified activities and metrics, and the NASA Center technology transfer offices are working to develop an implementation plan to move out on these activities in FY 2013. NASA's implementation plan is under review, and will be released through the Department of Commerce in the early part of FY 2013.

2. One of the stated objectives of NASA's Technology Transfer Implementation Plan is to engage the technology transfer process at all stages of development and to ensure that technology transfer is considered at the earliest phases of NASA program and acquisition planning. What will NASA do, in practice, to meet this objective?
   a. To what extent does meeting this goal require a culture shift and, if so, what is the most important thing you are doing to encourage such a shift?

   ANSWER: NASA is making a critical cultural shift in order to address this objective. The most important element is completion of the new Technology Transfer policy. This policy direction, along with training and awareness initiatives, will begin to impact the NASA culture increasing the visibility of technology transfer within the Agency. As in the past, this policy will dictate processes and procedures for reporting

[2] *Stevenson-Wydler Technology Innovation Act* of 1980

new technology, and have project managers thinking about what will require reporting earlier in the development life cycles. In addition, NASA has created a publically available website which will call out metrics and allow greater collaboration by widely disseminating released technologies and software licenses.

3. In your prepared statement, you say that NASA is *"restoring resources for technology assessments, bridge funding, market analysis, and marketing of technologies."* What is the justification for NASA's role in market analysis and the marketing of technologies?

ANSWER: NASA's market analysis and outreach activities are aimed at raising public awareness of technology transfer opportunities.

Consistent with legal requirements, most notably the Stevenson-Wydler Technology Innovation Act of 1980 and the Technology Transfer Act of 1986, NASA collects reports of its new technologies, assesses these reports, and then seeks intellectual property protection for the purposes of technology transfer. NASA must make strategic decisions about what to patent, as this is a research-intensive and costly process.

NASA, therefore, conducts market assessments to determine which of its technologies are best suited for patenting and transfer. It is part of the process by which the Agency down-selects from the large numbers of new technologies it develops each year and determines which ones to market to industry.

Market analysis is critical to the process of determining which technologies have the greatest potential in the commercial marketplace. This feature of our program enables us to be aware of development trends and innovation and identify marketable products and potential societal benefits.

QUESTIONS FOR THE RECORD
U.S. House Committee on Science, Space, and Technology
Subcommittees on Investigations & Oversight and Energy & Environment Joint Hearing

"Continuing Oversight of the Nation's Weather Satellite Programs: An Update on JPSS and GOES-R"

Wednesday, June 27, 2012

Mr. Marcus Watkins
Director, Joint Agency Satellite Division, National Aeronautics and Space Administration

<u>Questions submitted by Dr. Paul Broun, Chairman, Subcommittee on Investigations & Oversight and Dr. Andy Harris, Chairman, Subcommittee on Energy and Environment</u>

1) What are the outstanding technical issues for the sensors on JPSS? The GAO report indicated that they are experiencing issues but can you provide a more detailed update?

Answer:

Joint Polar Satellite System (JPSS) has five sensors in the payload complement: Advanced Technology Microwave Sounder (ATMS), Cross-track Infrared Sounder (CrIS), Ozone Mapping and Profiler Suite (OMPS), Visible Infrared Imaging Radiometer Suite (VIIRS), and Cloud and Earth's Radiant Energy System (CERES). All of these instruments are in various stages of manufacturing and testing, when technical issues related to parts and manufacturing are typically identified. All of these instruments were qualified in support of the Suomi National Polar Orbiting Partnership (SNPP) mission that launched in 2011.

As of August 2012, ATMS and CrIS have resolved their currently known technical issues. The OMPS instrument has had a series of problems with electronic boards including parts, connectors, and manufacturing processes. The Single Board Computers (SBC) were rebuilt and will be delivered to the OMPS vendor for testing in September. Other electronic board issues have been resolved.

The CERES instrument recently experienced issues with the internal calibration hardware, which is necessary for on-orbit performance. Retesting of the hardware is in process to determine the root cause of the problem. The CERES instrument was preparing for final acceptance review when the issue occurred. There is ample schedule margin to resolve the CERES issue before it is scheduled to ship to the spacecraft vendor for integration.

The design of the VIIRS instrument is technically difficult to manufacture. The primary issue with VIIRS has been the build and alignment of the Aft Optics Assembly containing the cryogenically cooled short/medium and long wavelength detectors. Problems with the build of the detector assemblies have been resolved and they are now working through alignment. The VIIRS SBC's are also being replaced due to on-orbit performance issues found on SNPP.

Of the JPSS-1 instrument suite, the VIIRS instrument is on the critical path. All the instruments' scheduled delivery dates support the current launch readiness date with more than acceptable margin, and in most cases significantly more. All technical issues uncovered thus far are manageable within the cost and schedule margins of the flight project. Mitigations have been put in place for identified risks, and acceptable margin is in place for future unknown issues.

2) The ABI has experienced some nontrivial technical challenges involving its wiring boards and signal problems in several of its infrared channels. Can you explain how these problems are impacting the schedule for developing this sensor and what corrective actions the contractor is undertaking to get it back on target with respect to cost?

Answer:

The Advanced Baseline Imager (ABI) instrument contractor had difficulty meeting the industry standard "IPC-6012B" specification for Printed Wiring Board (PWB) manufacturing. NASA and the ABI contractor (Exelis) evaluated the PWB deviations and made decisions to re-manufacture the boards that were critical to mission success. Other deviations were accepted as technically acceptable after test and inspection by NASA. As of this writing, all PWBs for all flight models have been received and have passed NASA inspection. To minimize schedule impact, Excelis and NASA were able to devise a test program that began testing with a combination of flight and non-flight PWBs until all flight boards were available. As a result, there was minimal impact on the overall instrument schedule.

The ABI Visible and Infrared channels were experiencing a problem with unintended light leaking into the optical path through the spectral filters. The problem was resolved by adding a blocking coating to the edges of the filters where the unwanted light was entering the system. The instrument has been reassembled and testing has confirmed that the fix was successful. The investigation and resolution of this issue resulted in an approximately seven-month delay in delivery of the ABI Flight Model-1. Nevertheless, the scheduled delivery date for the ABI Flight Model-1 still meets the date by which the instrument is needed (the need date) with margin for integration with the spacecraft.

The costs associated with resolving these issues are now unrecoverable; however, since these specific design issues are resolved, they will not cause a future cost overrun. The sunk cost represents an overrun on the ABI contract, but it does not increase the overall GOES-R life cycle cost because the GOES-R Flight Project was able to fully cover the cost impact using the funding it holds for development issues.

3) The GLM has also experienced some nontrivial technical challenges including electronics failing during testing, image signal problems, and emissions exceeding requirements. Can you explain how these problems are impacting the schedule for developing this sensor and what corrective actions the contractor is undertaking to get it back on target with respect to cost?

Answer:

The technical challenges encountered with the Geostationary Lightning Mapper (GLM) program have been exclusively with non-flight, "engineering development unit (EDU)" hardware, which is used as a tool to test and improve designs for the flight instrument build, thus ensuring a good GLM flight design. The three concerns cited in the question are:

- The initial EDU power-on failed and was found to be caused by corrosion on the power electronics board. Corrective action was implemented and new EDU boards were built resulting in a successful power-on.
- The image signal problems are the electrical crosstalk observed in the image during EDU testing. This issue was mitigated in the flight hardware design by improving the electrical isolation of the signal chain. A ground software filter has been also developed to remove the noise in the image. Scientists representing the user community have determined that the effect of electrical crosstalk, even uncorrected, would not prevent GLM from meeting its performance specification.
- The emissions exceeding requirements was observed during electro-magnetic compatibility (EMC) testing of the EDU, a test designed to ensure the electronics design was functionally viable prior to moving into to the flight build. To address the exceedances, a team of multidisciplinary technical experts was formed from a variety of organizations both within and outside of the GLM Program. This team reviewed the electronics and made multiple design changes to address the EMC exceedances.

The GLM electronics schedule has been impacted primarily by the EMC exceedances, which necessitated a significantly greater redesign effort than had been anticipated. The instrument delivery schedule was impacted by approximately 10 months. However, fabrication of the flight electronics is now underway with scheduled receipt of all boards supporting the integration and test of the GLM instrument and delivery according to the date by which the instrument is needed (the spacecraft need date).

The costs associated with resolving these issues are now unrecoverable; however, since these specific design issues are resolved, they will not cause a future cost overrun. The sunk cost represents overrun on the GLM contract, but it does not increase the overall GOES-R life cycle cost because the GOES-R Flight Project was able to fully cover the cost impact using the funding it holds for development issues.

The GOES R GLM is a new instrument capability that has never been flown before and is an exciting addition to the GOES-R complement of instrument capabilities to monitor and provide early warning of dangerous weather events. As with any development program, technical issues will arise and the Project's budget was structured to deal with such challenges.

The contractor and the government team are taking the following actions to reduce schedule and schedule risk, which should help avoid future cost increases:

- The contractor has assigned a dedicated production engineer to monitor daily progress on board fabrication. Each board is being individually tracked through the manufacturing process and actively ushered to the next process to avoid inadvertent "down time" in manufacturing.
- Two separate vendors are fabricating the boards in parallel to mitigate delays.
- GLM contractor is in the process of incentivizing their board suppliers for early delivery.
- GLM contractor has completed a dry-run of all instrument integration & test and calibration activities on the EDU to rehearse processes and procedures.
- Ground support equipment improvements have been identified to reduce instrument-handling times.

- GLM contractor is fabricating a second flight electrical harness and is considering fabricating a second flight electronics box, which can be delivered earlier than the remainder of the GLM instrument to keep the spacecraft integration on schedule even if there are further delays to the electronics.

Questions for the Record·
Submitted by Rep. Steven M. Palazzo, Chairman
Space and Aeronautics Subcommittee

"Examining NASA's Development of the Space Launch System and Orion Crew Capsule"
September 12, 2012

1. **SLS is designing to the 70 metric ton lift capability vehicle, and accepting risks that additional modifications to key components - such as the core stage - will be needed to support later versions of SLS. As a result, while costs for developing the current vehicle are flat, they could significantly escalate under the SLS designs. How is NASA planning to control costs for future designs of SLS? Does the program anticipate a budget wedge opening up once the 70 ton variant is largely complete?**

   A: NASA's block upgrade strategy for the Space Launch System (SLS) is intended to balance early mission demonstration and future mission requirements within a sustainable budget profile. NASA is designing the SLS as an evolvable vehicle that can support missions to a variety of destinations, based on mission requirements. In addition to the "Block 1" 70 metric-ton (mt) variant currently in development for the initial flights in 2017 and 2021, NASA is also engaged in design, development, and risk reduction activities for the planned follow-on, "Block 1A" 105-mt and "Block 2" 130-mt variants. Preliminary design work on the Core Stage will take into account manufacturing and design commonality between the Core Stage and future Upper Stage. Specifically, the SLS Core Stage's manufacturing facilities, tooling, materials, and processes/practices are common to the Upper Stage in both diameter (27.5 ft.) and basic design including the workforce, supply chain/industry base, logistics, and propellants. The Block 1 Core Stage is being designed to take into account the load environment for both the Block 1 and Block 1A/2 variants. SLS is also maintaining commonality of interfaces during evolution. NASA has issued research awards for advanced development and Advanced Booster risk reduction work that is directly tied to the follow-on development of the Block 1A and Block 2 variants. NASA is also continuing with an aggressive testing campaign for the J-2X engine (which will power the Upper Stage on the 130-mt variant). In total, these investments are intended to speed development of the initial Block 1 capability while reducing the technical and cost uncertainty of future block upgrades. Once the 70 mt variant is complete, available funding will be applied to development of the Advanced Booster and Upper Stage, which are required to evolve to the 130 mt capability.

2. **The Orion crew vehicle is facing a flat funding profile through 2017 and as a result has prioritized EFT-1 related activities while deferring development and testing of critical components needed for the first crewed flight, such as crew life support systems. What is the impact of deferring this work until later in the project's development?**

   A: NASA is executing an incremental development approach with Orion with the Exploration Flight Test-1 (EFT-1) article as the initial configuration and subsequent configurations (Exploration Mission-1 [EM-1] and Exploration Mission-2 [EM-2]) building up to the needed crew capability. With each increment significant development is accomplished and provides the basis for the subsequent increments.

   - EFT-1 will provide the development and flight test of the prime Orion structure, the reentry heat shield, initial thermal control, and initial communications and control. EFT-1 specifically addresses the mitigation of 10 of the top 16 contributors to loss of crew and loss of mission risks, including performance of the heat shield and thermal protection system, Forward Bay Cover deployment and other critical separation events, drogue and main parachute deployment, crew module up-righting system deployment, and launch abort system jettison. For the Environmental Control and Life Support System, EFT-1 will test the first environmental control components, including the active thermal control system pump package, the ammonia tanks, cold plates and valves.

- EM-1 will complete further development by including additional subsystems, secondary structure, and the next phase of environment control. Examples include the in-space propulsion and attitude control motors, solar arrays, heat radiators, additional pumps and active thermal control systems. Development of the life support components that will be tested on EM-1 in 2017 will begin in FY 2013.

- EM-2 development will complete the development for crew capability by completing the environmental control and life support systems, and adding the crew display and control systems. Development of life support components flying on EM-2 has already begun via internal Government efforts (these efforts include component development, build, and test for the Orion spacesuits).

This incremental development of Orion's life support system will support the 2021 crewed flight of Orion and SLS.

3. **The SLS will use heritage hardware from the Shuttle program that will need to be modified to operate as part of SLS, examples being the solid rocket boosters and the space shuttle main engines. When will the exact modifications to these components be known and how much depends on the design of the core stage? How confident is NASA that these modifications can be made in order to support the first uncrewed flight in 2017?**

   A: NASA has developed the SLS test program to enable the Agency to take advantage of investments made in the Shuttle and Constellation Programs. The Agency is currently going through a rigorous process to qualify the five-segment solid rocket boosters and RS-25 Space Shuttle Main Engines for use on SLS. This process is already well along, with the solid rocket booster qualification motor in manufacture today and scheduled for testing next summer, and Critical Design Reviews of both the booster and RS-25 scheduled for 2015. The RS-25 engines will be utilized for the first four flights of SLS without major modifications. The engine controller will be updated due to obsolescence and be made common with the J-2X controller. The five-segment boosters are completing final development and qualification to be used on the first two flights, EM-1 and EM-2. NASA is confident that the SLS development effort is on track to support the uncrewed EM-1 flight in 2017, with schedule margin in the timeline.

4. **I am concerned about how quickly NASA is proposing to do an asteroid mission. Based on agency comments, one could surmise that an asteroid visit may be the first operational mission of SLS/Orion. Depending on the asteroid chosen, I've heard that a mission may take anywhere from five to six weeks to several months. How does this approach align with a strategy of moving deeper into the solar system in a step-wise fashion? Is the plan to do a 2021 EM-2 mission, and then queue up an asteroid as the next destination?**

A: While the specific mission timing of the first crewed visit to an accessible near-Earth asteroid is yet to be determined, NASA is studying such a visit in the mid-2020s. This includes identification of suitable target asteroids in this timeframe as well as the capabilities and resources required to encounter such an object. The Agency will ramp up its capabilities to reach -- and operate at -- a series of increasingly demanding destinations, while advancing technological capabilities with each step forward. Initial mission capabilities could reach the vicinity of Earth's Moon, and the Earth-Moon Lagrange points. NASA can employ testing and early operations opportunities to assess operational procedures and methodologies, such as interplanetary station keeping, maneuvers and rendezvous, needed for missions to accessible near-Earth asteroids.

5. **I understand the Delta 4 cryogenic upper stage will be used on the initial set of flights. What is the schedule for developing a new upper stage powered by the J-2X engine? And as a follow-up, to what degree will a new upper stage require modifications and testing of the core stage?**

   A: As part of the Core Stage development effort, NASA is including the design of Upper Stage tooling. The J-2X-based Upper Stage will require additional design, development, test, and evaluation work on the stage itself, including the propellant feed system that will supply the J-2X engine. Testing of the J-2X is currently underway and the Core Stage development is accounting for the capability to add the Upper Stage. The additional Upper Stage design and development effort will be phased to support the mission needs and budget profile. The evolution of the Core Stage to accommodate the Upper Stage is an essential consideration for the current core design process.

6. **The operational costs associated with maintaining the Space Shuttle were unsustainable and NASA's intent under the Constellation program was to develop vehicles that required significantly less in terms of operational costs. Has this approach transferred to SLS and Orion programs and if so, what is the current estimate for operational costs of these vehicles?**

   A: Affordability and sustainability are key considerations of the SLS design and development process. Therefore, the SLS and Orion programs reflect NASA's intent to develop vehicles with reduced operating cost, as evidenced by key design trades conducted that weigh potential production and operations costs against similar historical applications as key considerations. At this point in the development of the systems, it would be premature to estimate overall operational costs for the full-up Orion or SLS; the Agency will develop production and operations cost estimates as it proceeds through the design, testing, and manufacturing of the initial flight vehicles. Additionally, NASA is evaluating a design-to-cost requirement to impose on Orion and SLS; however, we have not yet matured that requirement to implement.

7. **Your written statement says that NASA will "ramp up service module design efforts for 2017." Is the plan to use a service module in 2017 for the EM-1 test flight? How would you characterize the technical risk of designing and developing a fully functional service module?**

   A: The Service Module (SM) is the portion of the Orion MPCV that houses the spacecraft's power and propulsion systems, while the crew compartment is located in the Crew Module. Service Modules will be flown as part of all Orion flights, with key SM test objectives to be achieved on the EM-1 test flight. NASA and its contractors have been designing and developing service modules for crewed spacecraft since the 1960s (development of the SM is not seen as a major program risk), and Orion prime contractor Lockheed Martin is under contract to provide service modules for Orion. NASA is also in discussions with the European Space Agency (ESA) about the feasibility of using a service module design that is derived from ESA's Automated Transfer Vehicle design and the possibility of ESA building the Orion SMs for the EM-1 and EM-2 flights.

Questions for the Record
Submitted by Rep. Jerry Costello, Ranking Member
Space and Aeronautics Subcommittee

"Examining NASA's Development of the Space Launch System and Orion Crew Capsule"
September 12, 2012

1. **Given the need to complete development and flight testing of the core stage SLS and the Orion under limited funding, what is the rationale for NASA's decision to seek an advanced booster competition and development, which will require significant resources over time-rather than focusing limited funding on first completing development of the initial SLS and Orion, as well as the upper stage engine, which is already far along and required for the full SLS capability? What does a commitment to advanced booster development mean for the time line and availability of a completed upper stage engine?**

A: NASA's block upgrade strategy for SLS is intended to balance early mission demonstration and future mission requirements within a sustainable budget profile. NASA is designing the Space Launch System (SLS) as an evolvable vehicle that can support missions to a variety of destinations, based on mission requirements for both ascent and in-space performance. The Advanced Boosters and Upper Stage are required for the 130-metric-ton- (mt) capability required by law:

- The Advanced Boosters were phased into the budget profile in order to meet increased performance requirements for the 105-mt configuration, create competition to reduce booster costs, and support deep-space exploration missions after the Orion/SLS test flights of 2017 and 2021.
- The Upper Stage will be available to support the 130-mt configuration, which may be required for missions to Mars and some near-Earth asteroids.

This evolutionary approach underlies NASA's near-term, focused investments in Advanced Booster and Advanced Development activities, and is consistent with Congressional direction on SLS performance. While NASA intends to invest in Advanced Development and Advanced Booster risk reduction activities (investments which are vital to buying down the risk and ensuring the success of future SLS block upgrades), the Agency's immediate focus remains on ensuring that the first flight of the Block 1 SLS in 2017 stays on schedule and on budget.

2. **What is the detailed plan for evolving the initial SLS variant to the full 130 metric ton capability? When will NASA make decisions regarding the upper stage propulsion and advanced boosters required for the full capability? What criteria will be used in making those decisions?**
   a. **How will NASA ensure that work needed to get to the evolved capability will get done without slowing down work on the initial capability?**

A: NASA will evolve the SLS from an initial 70 metric ton (mt) lift capability to a 105-mt capability, and then to a 130-mt lift capability. These vehicle blocks all fulfill specific, important roles within the exploration architecture. The Block 1, 70-mt vehicle will prove out the new Core Stage and integrated stack for the initial exploration missions in 2017 and 2021, and can support scientific payloads with requirements beyond commercial lift capabilities. For missions beyond 2021, analysis has shown that the Block 1A, 105-mt vehicle provides significant "mission capture" for the next set of human expeditions beyond low-Earth orbit (LEO). Finally, the 130-mt Block 2 vehicle can be used for full capability asteroid missions and ultimately missions to Mars in the mid-2030s.

NASA will make the decisions necessary to execute the mission architecture as it evolves. Key decisions will include the phasing of the advanced booster efforts as compared to the Upper Stage efforts. These decisions will be made to support the mission and crew safety requirements, work within the budget, and recognize potential impacts to the industrial base and workforce skill impacts.

The Block 2 SLS configuration will require both a new Upper Stage using J-2X engines currently in development, as well as Advanced Boosters. NASA has initiated the first phase for the development of these advanced boosters. In July 2012, SLS completed the final selection for the Advanced Booster Engineering Demonstration and Risk Reduction NASA Research Announcement to improve the boosters' affordability, reliability, and performance. Four tasks were selected for negotiation, with awards of three tasks announced in October 2012. The fourth task required coordination with the U.S. Air Force and the award is planned for first quarter FY 2013. These initial risk-reduction tasks will be followed by another full-and-open competition for the full-scale design and development work leading to an eventual advanced booster for the evolved SLS. This future competition is planned for 2015 and will be acquired through a separate solicitation.

Please see response to Question #1 regarding the development of the initial SLS/Orion capability as NASA moves forward on the Advanced Booster effort.

3. **What steps is NASA taking in the design of SLS and Orion to promote safety? What do you consider the most significant safety challenges?**

A: Mission success requires uncompromising commitment to safety, and development of SLS/Orion is proceeding with the goal of creating a human spaceflight system that significantly reduces the risks to crew and vehicle when compared with previous systems. Among the most significant challenges are keeping the crew safe during the launch/ascent and entry/descent/landing phases of flight. The Orion spacecraft will use a Launch Abort System to provide protection for the Crew Module from atmospheric loads and heating during first-stage flight, and expand the envelope of survivable abort conditions over previous abort systems by providing active attitude control. The Crew Module will provide a safe habitat for the crew from launch through landing and recovery, and will conduct reentry and landing as a stand-alone module. The Program has already completed a number of water impact and parachute tests in various configurations, and fabrication of the state-of-the art heat shield has been initiated. Exploration Flight Test-1 (EFT-1) in 2014 specifically addresses the mitigation of 10 of the top 16 contributors to loss of crew and loss of mission risks, including performance of the heat shield and Thermal Protection System, Forward Bay Cover deployment and other critical separation events, drogue and main parachute deployment, crew module up-righting system deployment, and Launch Abort System jettison.

The SLS will also support the safety of the crew, in part through the use of proven, heritage elements in its propulsion systems. These include the RS-25 engines, based on the Space Shuttle Main Engine design and a 100 percent reliability record during 135 Shuttle missions; the J-2X Upper Stage engine, with design heritage going back to the Apollo Program; and (for the initial test flights) five-segment solid rocket boosters, which are an evolution of the Space Shuttle Solid Rocket Boosters. As Orion will fly on the top of SLS, the danger of the spacecraft being impacted by debris falling away from the launch vehicle will be eliminated.

Questions for the Record
Submitted by Rep. Dana Rohrabacher
Space and Aeronautics Subcommittee

"Examining NASA's Development of the Space Launch System and Orion Crew Capsule"
September 12, 2012

1. **What portion of the recurring cost is the DoD willing to pick up to launch military payloads aboard the Heavy-lift Launch Vehicle?**

   A: NASA is primarily focused on developing the SLS launch vehicle and the Orion MPCV spacecraft to provide the United States with a human capability to explore space beyond Earth orbit by 2021. NASA acknowledges this capability will be a national asset, one that can be used to the benefit of other national interests. With this capability in work, NASA has reached out to the science and military communities, providing estimated lift capability of the SLS launch vehicle. Potential requirements from these communities are being discussed and will continue to be assessed as the launch vehicle development progresses and more detailed capability information can be shared. There are as yet no requirements for the SLS from the Department of Defense (DoD) and no funding is requested from the DoD for SLS development and operations.

   In September 2012, NASA selected 26 proposals from academia and industry for advanced development activities for the SLS. Proposals selected under this NASA Research Announcement (NRA) seek innovative and affordable solutions to evolve the launch vehicle from its initial configuration to its full lift capacity capable of sending humans farther into deep space than ever before. NASA sought proposals in a variety of areas, including concept development, trades and analyses, propulsion, structures, materials, manufacturing, avionics and software. NASA is partnering with the U.S. Air Force on this research announcement in support of common national rocket propulsion goals.

   The proposal selections are the first step in the NRA procurement process. The second step, formal contract awards, will follow further negotiations between NASA and selected organizations. All proposals will be valid for 12 months to allow for a later award if the opportunity becomes available, unless the offeror withdraws the proposal prior to award. Successful offerors to this NRA will not be guaranteed an award for any future advanced development acquisition.

2. **Can NASA improve the SLS affordability by having commonality with EELV ... having common systems supporting both NASA and national security missions?**

   A: NASA is actively working to address lessons learned from the Evolved Expendable Launch Vehicle (EELV) program, particularly as it applies to more efficient and less costly operations. In addition, NASA is assessing the use of EELV common avionics systems for SLS. The Agency's emphasis on SLS affordability includes looking across the existing U.S. launch industry for cost saving opportunities. For example, NASA is looking to leverage common manufacturing and industry design and construction standards into the SLS design, where appropriate. SLS will also use aircraft-grade aluminum 2219, rather than aluminum lithium 2195, for Core Stage construction, which while adding approximately 3,000 pounds has the potential for saving up to $30M per Core Stage. NASA is also exploring opportunities to leverage launch industry investments in avionics, engine controllers, and other areas to reduce design, development, production, and operations costs.

3. **The SLS and Orion will be capable of transporting astronauts to multiple destinations beyond LEO. While the plan calls for the initial destination for human flight beyond LEO to target an asteroid by 2025, there are other viable destinations including cis-lunar space such as the Earth-Moon Lagrange points, the lunar surface, and eventually Mars and its moons.**
    a. **Where does NASA think the near-term destination should be?**
    b. **What destinations can you reach with the 70 mT? 105 mT?**
    c. **How would that change with Block 2 or the 130mT?**

    A: In the near term, NASA is studying a crewed visit to an accessible near-Earth asteroid in the mid-2020s. The specifics of the destination will continue to be informed by what the Agency learns in the next few years through surveys and identification of candidate asteroid targets.

    NASA will evolve the SLS from an initial 70 metric ton (mt) lift capability to a 105-mt capability, and then to a 130-mt lift capability. These vehicle blocks all fulfill specific, important roles within the exploration architecture. The Block 1, 70-mt vehicle will prove out the new Core Stage and integrated stack for the initial exploration missions in 2017 and 2021. For missions beyond 2021, analysis has shown that the Block 1A, 105-mt vehicle provides significant "mission capture" for the next set of human expeditions beyond low-Earth orbit (LEO) in preparation for follow-on missions. Finally, the 130-mt Block 2 vehicle may be used for full-capability asteroid missions and ultimately missions to Mars in the mid-2030s. The smaller SLS variants could also support the full-capability asteroid and Mars missions, but additional launches would be required.

4. **What is the expected recurring or launch cost for SLS/Orion?**
    a. **Can you break the cost estimates down in terms of fixed vs. variable costs?**

    A: The SLS and Orion programs reflect NASA's intent to develop vehicles with reduced operating cost. At this point in the development of the systems, it would be premature to estimate their operational costs; the Agency will develop production and operations cost estimates as it proceeds through the design, testing, and manufacturing of the initial flight vehicles.

5. **Given that the President's FY 2013 budget request had notional figures for the out years, what funding levels are required in the out years for SLS to meet its target date of 2017 for the EM-1 mission?**

    A: The President's FY 2013 Budget Request level of $1.9 billion per year in the outyears will support the 2017 target launch date for Exploration Mission-1 (EM-1). This funding includes SLS development, program integration and support, Exploration Ground Systems funding, and – in FY 2013 – programmatic Construction of Facilities in the Construction and Environmental Compliance and Restoration account, as directed by Congress.

Questions for the Record
Submitted by Rep. Eddie Bernice Johnson
Space and Aeronautics Subcommittee

"Examining NASA's Development of the Space Launch System and Orion Crew Capsule"
September 12, 2012

1. **Under NASA's current plan, the first crewed flight of Orion and SLS won't occur until 2021. What critical measures would need to be taken to achieve a crewed SLS/Orion flight capability in *this* decade? Are the constraints technical or budgetary? Under the current budget plan, you are losing purchasing power due to inflation. If you received inflation-adjusted flat funding, could you pull the first crewed flight forward in time? If so, by how much?**

   A: NASA has developed an executable plan to develop the Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV) systems to support the first human flight in 2021. There are multiple variables involved, both technical and budgetary, in phasing the development of SLS, Orion, and the Exploration Ground Systems effort, and the Agency does not have an estimate for the impact on the 2021 launch date of inflation-adjusted flat funding. NASA will re-evaluate the projected 2021 launch date over the next few years to assess the potential for the integrated Orion MPCV, SLS, and Ground Systems capabilities to support an earlier launch opportunity.

Questions for the Record
Submitted by Rep. Hansen Clarke
Space and Aeronautics Subcommittee

"Examining NASA's Development of the Space Launch System and Orion Crew Capsule"
September 12, 2012

1. **Given the current funding situation facing the SLS and Orion programs, what is the rationale for funding development of a multipurpose launch pad for the exploration program at this point instead of just focusing on a pad to support SLS operations? What vehicle, other than SLS, would use it, and if you don't yet know, how will you determine the launch pad requirements?**

   A: The Exploration Ground Systems (EGS) development activities are focused on the development of the necessary ground systems and operations plans and procedures to prepare, assemble, test, launch and recover the exploration architecture elements for long-term beyond-Earth orbit (BEO) exploration, currently the Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV). The 21st Century Space Launch Complex (CSLC) initiative is a focused set of investments to repair, upgrade and modernize launch infrastructure to support multiple users (commercial and Government) of facilities and services. The infrastructure improvements are needed for SLS and also support other potential users.

   There has been interest from commercial entities in utilizing launch pad 39-B at KSC; however, no firm commitments or requirements had been agreed to as of October 2012. The NASA Ground Systems Development and Operations office, which manages the EGS Program and 21st CSLC initiative, continues to look for ways to share facility operations costs with multiple customers across industry and government to benefit all users.

   It is important to note that, while NASA anticipates some multipurpose applications from the EGS Program, the purpose of that effort is to support SLS/Orion operations, and EGS activities are being driven by the requirements of those systems.

2. **Inspiration is an intangible but critical element in maintaining the momentum and support for space projects. What decisions and actions will be most effective in stimulating and sustaining excitement in the SLS/Orion program?**

   A: NASA has engaged learners and educators in its engineering challenges and scientific discoveries since its inception. From school presentations to seeds flown in space, from filmstrips and posters to podcasts and virtual tours through the galaxies, NASA's education programs have fostered inquiry, built curiosity and encouraged innovation. As the Agency plans and executes major milestones, including the uncrewed Exploration Flight Test-1 (EFT-1) in 2014, the first uncrewed launch of Orion and SLS in Exploration Mission-1 (EM-1) in 2017, and the first crewed launch of Orion and SLS in Exploration Mission-2 (EM-2) in 2021, it will take advantage of the technical achievements to inspire a new generation of scientists and engineers. SLS/Orion content can be incorporated into new engineering design challenges and competitions, educator professional development, and the creation of apps that reach youth in new and exciting ways. Through innovative partnerships, NASA has forged relationships with dozens of organizations and hundreds of museums/science centers that translate NASA's innovations into inspiring and engaging educational experiences. These will expand to include the new experiences and engineering challenges undertaken by the SLS/Orion program.

Questions for William Gerstenmaier
From Chairman Ralph Hall
September 14, 2012 Hearing on
Recent Developments in NASA 's Commercial Crew Acquisition Strategy

1. If these CCiCap awards were made under a FAR-based selection process, how would the decision process have been different?

   ANSWER: Regardless of the award instrument (funded SAA or FAR-based contract), NASA follows a similar evaluation/selection process to ensure that the integrity of the competition is maintained. Some of the specific steps taken for CCiCap include conducting an Agency level strategy meeting, appointment of an evaluation team, a documented evaluation plan, documented evaluation based on the criteria stated in the competition announcement, a formal presentation to the Source Selection Authority and consultation with internal advisors, and documentation of the selection decision.

   - What additional aspects would NASA have had to consider under a FAR-based selection process?

   ANSWER: For any competition, what needs to be considered in the selection process depends on the specific circumstances of the acquisition and the nature of the award instrument. For CCiCap, the selection process focused on the proposers' technical plans and resources to meet the stated objectives of the activity.

   - What factors were eliminated from consideration by the SAA-based selection decision that would have affected a FAR-based selection?

   ANSWER: In determining the CCiCap SAA-selection decision process, NASA did not take the approach of eliminating what was not needed for a FAR-based selection. Rather, NASA developed the CCiCap selection criteria by considering what was needed in order to meet CCiCap objectives and conduct a fair competition.

2. Were CCiCap participants advised on a minimal, optimal, or requested level of private investment?

   ANSWER: The CCiCap Announcement for Proposals listed as a strategic goal, "Achieving significant industry financial investment." Specific amounts of industry investment were left to the companies to determine based on their financial situation, the overall costs of their system, and their business plan.

3. How will NASA verify the level of private investment that is contributed to the program?

   ANSWER: Partner investment levels are usually provided to NASA during each company's Quarterly Status Meetings. In addition, some of the CCiCap partners included financial/business milestones as part of their Space Act Agreements and NASA must determine if those milestones have been successfully completed. Those milestones may include the level of private investment and other financial information associated with their development effort.

4. If NASA determines that the companies are not contributing the level of funds originally agreed to in the CCiCap proposals, what recourse will NASA take?

   ANSWER: For COTS Cargo, CCDev1, and CCDev2, the partners have indicated that the level of private contribution met or exceeded the amounts included in their respective proposals. Since the funded Space Act Agreements include a fixed government investment, the partners are responsible for any additional monies required to meet the agreed-to milestones.

   If the partner does not contribute the level of private investment indicated in its proposal and if that underfunding results in the partner missing a milestone, then NASA can terminate the SAA if it is determined to be in the best interest of the government. If the partner successfully completes its milestones, then no recourse is necessary as the company has met the legal requirement of the SAA, which is performance of the milestones.

5. If the company's contributions are inadequate to ensure that the government's requirements and needs will be met, at what point in the process will NASA terminate the Space Act Agreement?

   ANSWER: See answer to question #4. NASA reviews missed milestones on a case-by-case basis to determine if it is in the best interest of the government to terminate the Agreement as a result of the missed milestone.

6. Given that the Liberty launch vehicle proposal used NASA heritage solid rocket boosters, and the European Space Agency's Ariane 5 booster, and a crew capsule and launch abort system with NASA heritage, please explain why ATK's proposal ranked so low on technical rating?

   ANSWER: As stated on page 10 in the "Selection Statement for Commercial Crew Integrated Capability", the rationale and ratings for ATK's proposal are as follows: "ATK was rated the lowest of the four proposals in Level of Effectiveness for Technical Approach, with a rating of WHITE (Moderate). The Proposal Evaluation Panel (PEP) also identified more technical weaknesses (3) for ATK than for the other proposals. The first two of these three weaknesses would have a significant effect on the ability of ATK to meet the goals of the Announcement. The PEP also had a Technical Level of Confidence rating for ATK of LOW, which was the lowest of all proposals. Based on the PEP findings on technical approach, [the Source Selection Authority] found the ATK proposal to be the weakest of the four proposals. Specifically, while the proposal described the use of a particular spacecraft design as a point of departure for the Liberty spacecraft and the use of heritage systems, the proposal did not include enough data to understand the spacecraft baseline configuration that would serve as the starting point, the system changes planned to bring this spacecraft to the Liberty baseline, or how heritage systems will be modified and integrated to enable a CTS capability. The use of heritage components alone does not relieve the requirement to define a plan for development using these components. The proposal identified systems integration as a significant program risk, but did not provide sufficient information on how the systems integration risk would be mitigated. In addition to this lack of detail, the proposed schedule was very aggressive without enough information to satisfy [the Source Selection Authority] on the credibility of the schedule. It was not clear how ATK plans to integrate the spacecraft, launch vehicle, and ground missions systems within the proposed schedule. All these elements combined causes significant concern regarding schedule integrity, which could negatively affect ATK's development cost. Basically the proposal lacked enough detail to determine if a safe crew transportation system could be developed in a timely and cost effective manner out of the heritage components ATK selected for this concept. The proposal recognized changes needed in these heritage systems and new integration activities, but did not provide a path to understand how these changes and integration activities would occur. Understanding these changes to heritage systems or the process for managing these changes is critical to understanding the viability of the overall proposal, and the integration work required can also dominate the effort if not controlled. The proposal correctly identified the integration risks, but did not offer a sufficient approach to manage this risk. It was for these reasons that [the Source Selection Authority] ranked ATK significantly lower than the other three proposals."

7. The costs for Atlas 5 EELV have increased significantly, yet three of the CCiCap awardees are planning to use that launch vehicle. How does NASA expect to produce cost savings in the commercial crew program using the same launcher that the Air Force is seeing increase?

    - Is NASA getting a cheaper price than the Air Force?

ANSWER: The launch vehicle is only one piece of the overall Crew Transportation System. Other cost drivers include the spacecraft, launch pad, and mission and ground operations.

Cost savings are expected because NASA is using competition and following a non-traditional strategy featuring: fixed government investment, industry financial contributions, high level requirements that allow tailoring of each partner's proposed approach to satisfying the requirements, lean program management, and incentives for the Partners to attract non-government customers.

8. In your response to a question about the cost savings that have resulted from the commercial cargo program, you said, "In the case of cargo, I can't give you a specific number of what we saved, but if you look at the launch costs and the cargo delivery, it is substantially less by using the Space Act approach than actually acquiring the services under the FAR part 12 contract for the actual delivery of services. So that has been a significant savings to us." Under the FAR-based Commercial Resupply Services contracts, what is NASA's negotiated composite cost per kilogram of payload?

ANSWER: This material is considered Sensitive But Unclassified because there are only two providers and a composite price is enough information to give each company insight into its competitor's pricing. This information can be provided to the Committee under separate cover.

9. In a follow up question about the cost savings that have resulted from the commercial cargo program, you said, "I think the risk in the case of cargo was schedule. We got the systems delivered to us later than we would have desired but we were able to extend the shuttle with an extra flight that made that risk tolerable to have that schedule delay acceptable to us overall." What was the cost of the extra shuttle missions that were required as a result of the delays of the commercial cargo program?

   ANSWER: NASA was statutorily required to extend the Shuttle program – the extension was not due to delays in the commercial cargo program. Per NASA's post-Columbia operational procedures, NASA retained a launch-on-need capability to support Space Shuttle flight STS-134, which meant there was a full set of flight hardware (including a prepped Orbiter, engines, external tank, and solid rocket boosters) standing by in case there were any issues with STS-134 that required a rescue mission. When STS-134 landed safely on May 30, 2011, that LON hardware became available to fly STS-135. Therefore, the cost of flying the STS-135 mission (which carried nearly 10,000 pounds of supplies to the ISS) was only the marginal cost of keeping the operational capability and personnel around for an additional two months, through the safe landing of STS-135 in July 2011. Those costs (i.e. for two additional month of Space Shuttle operations) were approximately $356M.

10. Your written testimony states that having dissimilar crew transportation services is 'critical' to effective utilization of the International Space Station. Is NASA committing to contracting with two launch services providers, or does it expect to only have one U.S. provider?

   ANSWER: Today, we only have one crew transportation capability, the Russian Soyuz. NASA is working to ensure that the United States ends its reliance on foreign crew transportation to the International Space Station (ISS) and utilizes a safe, cost-effective U.S. crew transportation capability. Competition is critical for maintaining a cost-effective capability and avoiding a monopoly, so we are hoping to support multiple launch service providers. The final number of launch service providers will depend on the level of funding for the Program and the outcome of subsequent competitions.

11. Based on NASA's CCiCap acquisition plan it appears the agency intends to solicit and award a services contract about halfway through the phase 2 certification contract. Please explain how NASA will evaluate the compliance and suitability of competing proposals when they are nine-months to one-year shy of completing their phase 2 work?

   ANSWER: While the exact strategy is still being finalized, the evaluation will consider compliance with requirements, processes and overall mission suitability by assessing partner progress as they mature their commercial crew transportation systems past design and through the majority of large scale systems testing during the two-phased certification contracts. This approach will allow NASA to gain the necessary insight into our partners' ability to develop, demonstrate and certify their transportation system as NASA prepares for future contracts.

Questions for William Gerstenmaier
From Acting Ranking Member Donna Edwards
September 14, 2012 Hearing on
Recent Developments in NASA 's Commercial Crew Acquisition Strategy

1. As NASA has acknowledged, risks are higher using an SAA because the agency does not have approval authority over how companies are meeting those requirements.

    a. How is NASA addressing the risk of commercial partners potentially not meeting NASA safety or performance requirements at the end of the base CCiCap period?

ANSWER: On December 10th, NASA announced plans to address this risk by awarding 3 FAR-based fixed-price contracts to begin early certification activities. These contracts are referred to as Certification Products Contract(s) (CPCs). The scope of the CPCs include submittal and technical disposition of specific, early lifecycle certification products, such as alternate standards, hazard analyses, a certification plan, and a verification & validation plan. This will be followed by a Phase 2 Certification procurement which will complete activities necessary to certify the crew transportation systems as safe enough to carry NASA personnel.

    b. What will NASA do if designs produced do not meet NASA's safety and performance requirements and are deemed unacceptable?

ANSWER: NASA will not fly NASA astronauts on transportation systems that do not meet our safety requirements.

    c. If NASA requires redesign or rework of completed systems, what impact will this have on costs and schedule? Who will pay these added costs?

ANSWER: NASA has not determined how cost increases associated with redesign or rework in order to meet NASA requirements will be handled for future phases. Schedule impacts would be based on the magnitude of the specific redesign or rework tasks. NASA plans to address these issues in the Phase 2 certification acquisition.

2. At the hearing, you indicated that NASA would consider using some of the CCiCap optional milestones.

    a. Wouldn't funding any of the CCiCap optional milestones undercut the whole purpose of the FAR-based certification phase contracts, which is preserving NASA's ability to mandate that its requirements be met and to provide NASA with the documentable need to verify that fact?

ANSWER: No. Funding selected optional milestones during CCiCap would not impact plans for the FAR-based certification contracts; rather conducting selected milestones during CCiCap could help mature partner systems and mitigate risks that could impact planned certification efforts.

b. Are there any conditions under which you would fund the optional milestone of a crewed flight to the ISS? If so, what are they?

ANSWER: NASA is not planning to do so at this time.

3. ASAP testified that NASA's latest acquisition strategy seems like an overly complex approach.

a. If the rationale for switching to Space Act Agreements was funding uncertainty, what makes NASA believe that the FAR-based certification contracts won't be subject to that same funding uncertainty?

ANSWER: NASA's decision to use Space Act Agreements for the current phase of the Commercial Crew Program was based on several factors, only one of which was future funding uncertainty. Given that funding levels have been below requested levels in the past and that uncertainty in out-year funding levels would still exist, there was a risk that NASA will not receive the funding required to support multiple providers under fixed-price contracts. Terminating or renegotiating fixed-price contracts under such circumstances could result in excessive costs and delays. SAAs offer much more flexibility as they can be terminated and/or renegotiated in a much more expedited pace, if required.

NASA intends to use FAR-based contracts in order to move to the next phase of certification activities to ensure that the Agency's CTS requirements are met. Funding uncertainty has the potential to cause the same type of issues under the certification contracts as it has posed in past phases.

b. If NASA believes that FAR-based contracts are needed, why not make the whole acquisition FAR-based instead of the current patchwork approach?

ANSWER: The SAA/FAR approach provides the lowest cost, highest flexibility approach to developing U.S. crew transportation systems. NASA is confident that Space Act Agreements provide the most cost-effective approach by which our partners can be innovative, creative, and flexible in their design solutions to develop commercial crew transportation capabilities. Using FAR-based contracts, NASA will ensure requirements, standards, and processes for certification for commercial transportation systems are held to the same safety standards as Government human spaceflight missions. The current approach captures the benefits of each approach.

4. Your Source Selection Statement identifies one of the five CCiCap strategic goals as "Achieving significant industry financial investment". Yet, it appears that on average, the companies are only willing to assume little more than a 10 percent share of the cost of developing their 'systems.

a. Given that, why did you accept any of their proposals?

ANSWER: Proposals were accepted because our partners demonstrated their ability to technically accomplish CCiCap development activities while showing their commitment to the program through their investment. There were no industry financial investment goals specified for CCiCap. Additionally, since NASA's CCiCap investments are fixed, additional costs required to accomplish development milestones will be financed by our partners at no risk to the government. Importantly, the cost of each of the systems was far lower than we would expect a traditionally procured system to cost. For example, NASA told the Augustine Committee that the Ares I rocket and Orion capsule would cost about $24 billion dollars. Development of these new systems could cost as little as one tenth of that amount.

b. Why didn't you either tell them that they had to contribute a higher cost share, or alternatively, scrap the SAA approach and go back to your FAR-based acquisition strategy, since the government is paying almost all of the development costs?

ANSWER: Proposals were accepted because our partners demonstrated their ability to technically accomplish CCiCap development activities while showing their commitment to the program through their investment. There were no industry financial investment goals specified for CCiCap. Additionally, since NASA's CCiCap investments are fixed, additional costs required to accomplish development milestones will be financed by our partners at no risk to the government. Importantly, the cost of each of the systems was far lower than we would expect a traditionally procured system to cost. For example, NASA told the Augustine Committee that the Ares I rocket and Orion capsule would cost about $24 billion dollars. Development of these new systems could cost as little as one tenth of that amount.

5. Your Acquisition Strategy White Paper states that to ensure NASA crew safety, "CTS Certification will validate technical and performance requirements, verify compliance with requirements at the subsystem level, process level and safety product level, validate that the CTS operates in the appropriate environments, and accept residual risk to NASA based on the governance model."

   a. How does NASA establish when residual risk is deemed "acceptable" and "unacceptable"?

ANSWER: NASA is committed to managing the Crew Transportation System (CTS) certification process to ensure that commercial missions carrying NASA crews are held to the same or equivalent Agency human space flight safety standards, as well as residual risk identification and acceptance practices, as with other NASA human space flight missions. This process includes not only CTS certification prior to the first NASA mission but also on-going certification of flight readiness for each subsequent NASA mission throughout the CTS service life. In conducting CTS certification activities over the program lifecycle, NASA will utilize standard Agency governance processes to identify, evaluate, mitigate, and disposition risks as an integral component of Agency decision-making that culminates in the granting of NASA certifications.

In accordance with the NASA governance model, risk management decision authority resides with Commercial Crew Program (CCP) Manager and ultimately the NASA Associate Administrator (AA) for Human Exploration & Operations Mission Directorate (HEOMD) and the NASA Associate Administrator. The CCP Manager will be advised by diverse subject matter experts from the Agency Independent Technical Authorities (Safety and Mission Assurance, Health and Medical, and Engineering), the Astronaut Office, the International Space Station Program, and other supporting organizations across NASA who will evaluate CTS design, development, test, verification, validation, and operations information to assess CTS requirements compliance, safety hazards and controls, and residual risk. The CCP Manager will make risk disposition decisions within CCP control board forums, which include voting representation from the NASA Independent Technical Authorities. The CCP Manager will keep HEOMD apprised of residual risk decisions that impact certification. Risk decisions or concerns that cannot be resolved within the Program or Mission Directorate, will be elevated to the Agency Program Management Council (governed by the NASA Associate Administrator) for a determination on NASA's acceptance of risk. The CCP Manager will make CTS certification recommendations during key Agency-level milestones where final NASA decisions will be made to grant CTS certifications.

During CTS certification, the measure of residual risk acceptability will be fully consistent with NASA policy and standards for all human space flight programs. Final decisions on whether residual risk is deemed "acceptable" or "unacceptable" will be based on assessed compliance with NASA human rating requirements, which embody over 50 years of space flight experience, lessons learned, and best practices. These NASA human rating requirements include design, manufacturing, workmanship, test, verification, and operations standards used to mitigate risks inherent in human space flight to an acceptable level. NASA Certification will be granted only after review of objective evidence that demonstrates CTS compliance with NASA requirements as well as appropriate mitigation of risks to crew safety and mission success. This includes inspection of plans and technical results associated with CTS design, test, verification, and past flight performance. Objective evidence will also include the Commercial partner's system safety assessments, which will be developed in accordance with the NASA Safety Review Process to assure consistent content and characterization of risk. These products will contain hazard analyses, which use both qualitative and quantitative techniques to identify and characterize all residual risks, which will be evaluated by NASA to assess whether CTS design decisions as well as safety hazard mitigations and controls established by the Commercial partner are sufficient to ensure crew safety and mission success. NASA approval of the Commercial Partner's compliance with requirements as well as CTS safety and reliability products and associated hazard analyses will represent NASA's formal acceptance of CTS residual risk.

There are always risks and uncertainties associated with the design and operation of complex human space flight systems in harsh environments. NASA is committed to understanding the CTS risks, ensuring risks have been mitigated to the maximum extent possible within programmatic constraints (technical, cost, schedule), communicating residual risks to stakeholders, and making informed decisions regarding final acceptance of residual risk. Ultimately, NASA will decide the acceptability of residual risk based on the best available engineering data and expert advice from across the Agency that leverages our collective human space flight knowledge base and lessons learned.

b. What relationship does that risk have to a governance model?

ANSWER: NASA is committed to managing the Crew Transportation System (CTS) certification process to ensure that commercial missions carrying NASA crews are held to the same or equivalent Agency human space flight safety standards, as well as residual risk identification and acceptance practices, as with other NASA human space flight missions. This process includes not only CTS certification prior to the first NASA mission but also on-going certification of flight readiness for each subsequent NASA mission throughout the CTS service life. In conducting CTS certification activities over the program lifecycle, NASA will utilize standard Agency governance processes to identify, evaluate, mitigate, and disposition risks as an integral component of Agency decision-making that culminates in the granting of NASA certifications.

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6. Almost all of the studies available to date examining the cost of commercial crew transportation systems on a per seat cost basis include, as a cost component, associated development costs. This makes sense since the eventual litmus test of which alternative is better requires consideration of the government's total investment. How will costs spent as part of NASA's commercial crew development activities--CCDev, CCDev2, CCiCap, CPC, and Certification Contract-factor into the comparison between the seat costs using commercial providers and that using the Russian Soyuz? If such development costs are not factored into the comparison, how can this be a credible comparison?

   ANSWER: A number of methodologies could be reasonably applied when comparing commercial crew transportation systems to other means of transporting people to low-Earth orbit. NASA has not determined how costs will be compared to the Russian Soyuz in the future.

7. During the hearing, referring to the Soyuz, you indicated that you needed an alternate way to get to the ISS. You also said that your intent was to use the domestic commercial carrier for all transportation to and from the ISS and that Soyuz transportation would no longer be required.

   a. With the possibility of a single commercial provider for operational services, wouldn't NASA be in the same position it is in currently, namely having no alternate way to the ISS?

ANSWER: Yes, however there would still be a way to and from the ISS. This was the scenario that NASA faced after the Columbia tragedy. The U.S. system could also back up the Soyuz. In addition, one of the tenets of the program is competition so NASA is exploring ways the U.S. could carry two domestic providers.

b. Does this call for the establishment of a contingency approach in conjunction with the award for commercial crew services?

ANSWER: NASA plans to transition to U.S. commercial crew providers when those systems are ready. The numbers of providers, specific mechanisms, contingencies, and inclusion of international partner vehicles have not been established.

c. How would this affect what NASA needs as part of any potential INKSNA legislation?

ANSWER: On January 14th, 2013, the President signed the Space Exploration Sustainability Act (Public Law 112-273), which included an amendment to the Iran, North Korea, and Syria Non-proliferation Act. The Act's amendment to INKSNA clearly enables NASA support for the acquisition of U.S. crew and cargo transportation services to the ISS that utilize Russian space capabilities through 2020.

Questions for William Gerstenmaier
From Congressman Randy Neugebauer
September 14, 2012 Hearing on
Recent Developments in NASA 's Commercial Crew Acquisition Strategy

1. NASA will allow companies to propose alternative standards to agency requirements. Assuming current standards reflect decades of experience gained from launching a variety of previous vehicles, what is the most effective and objective method of assessing the soundness of a proposed alternative standard? What steps will NASA take to ensure that adopting an alternative standard in no way diminishes the level of safety?

   ANSWER: NASA will assess partner proposed alternate standards to ensure these standards meet or exceed current system safety requirements as measured against existing NASA standards. These assessments will be conducted by NASA engineering, safety and health and medical Technical Authorities (TA). The TAs will present finding to the Commercial Crew Program for final disposition and alternate standard acceptance or disapproval.

2. Why isn't there more synergy and cross-investment between NASA's SLS and Orion programs and NASA's Commercial Crew program? Why hasn't NASA leveraged the investments from Constellation to support commercial crew designs?

   ANSWER: NASA outlined our requirements related to what the commercial crew transportation systems need to do, rather than detailing how to meet requirements. NASA's commercial crew partners are free to leverage Constellation experience and knowledge as well as other NASA investments to help them meet the goal of developing effective crew transportation systems. For example, several commercial crew partners currently have Space Act Agreements with several centers to utilize existing NASA resources. In addition, the commercial crew partners have requested access to several dozen technical documents from the Constellation Program. Thus, NASA and industry are levering the experience and lessons learned from Constellation.

QFR submitted by Roscoe G. Bartlett
Subcommittee on Tactical Air and Land Forces
F-22 Pilot Physiological Issues
Thursday, September 13, 2012

Question for: Mr. Clinton Cragg

14) Were you provided access to any Air Force data or facilities your team deemed necessary to carry out your review of the Air Force's investigative process and root-cause analysis?

14. Yes, the USAF provided the NASA Engineering and Safety Center (NESC) F-22 Life Support System (LSS) Independent Analysis Team with access to all of the data and facilities needed.

15) You mentioned in your written statement that you believed insufficient human-systems integration testing was accomplished before operational deployment of the F-22. What additional testing do you believe should have been accomplished?

15. One of the NESC's Team's recommendations was to ensure appropriate human system integration testing is performed before operational use of any new system or implementation of a change to an existing system. Life support components (e.g., the On-Board Oxygen Generator (OBOGs)) were all individually qualified and put into the system by a system integrator. The original F-22 qualification testing did not utilize the same Aircrew Flight Equipment (AFE) that is in use today. Many of the complex interactions between the end-to-end system and the pilots were just recently identified during the human centrifuge and altitude chamber testing.

16) You noted in your written statement that in any jet fighter environment, irritant compounds like combustion exhaust gases, fuels, lubricants, and organic cleaning solvents can be present. Are you confident in the Air Force's analysis that irritant compounds could not be in the pilot's breathing air supply thereby causing hypoxia-like effects?

16. As stated, irritant compounds are present in any jet fighter environment, including the F-22. The NESC Team found no evidence of a contaminant producing a toxic exposure for the pilots flying the F-22. The NESC Team recommended that the USAF "Consider a fundamental reassessment of requirements and assumptions for LSS in high performance aircraft." Such an assessment would provide a better understanding of the physiological effects of irritant compounds in high performance aircraft.

17) What is the status of the NASA Engineering and Safety Center report, and when will it be released? Would you provide the committee a copy of the report when it is completed?

17. The USAF requested NASA's review of hypoxia-like issues with the F-22. On August 31, 2012, the NESC presented the USAF with the final report. Accordingly, the USAF is

responsible for any further use or release of the report, and NASA has agreed to defer to the USAF on such requests. .

18) Are you confident that, in addition to removing the filter, improvements to the pilots' gear, such as the upper pressure garment, will fix the F-22's physiological problems?

18. The NESC Team believes that there are multiple issues affecting the pilot's physiology in the F-22. Addressing each of these issues will ensure that the hypoxia-like symptoms will become less likely. Removing the C2A1 filter that exacerbated the problems and fixing the Upper Pressure Garment are major improvements.

QFR submitted by Runyan, Jon
Subcommittee on Tactical Air and Land Forces
F-22 Pilot Physiological Issues
Thursday, September 13, 2012

Question for: Mr. Clinton Cragg
26) Do you think that you have found the actual cause of the problem? What is the source of the "Raptor cough"?

26. The NESC Team believes that there are multiple issues affecting the pilot's physiology in the F-22. Addressing each of these issues will ensure that the hypoxia-like symptoms will become less likely. Removing the C2A1 filter that exacerbated the problems, adjusting the oxygen schedule down from "Max," and fixing the Upper Pressure Garment are major improvements. The NESC Team believes that the "Raptor Cough" is likely caused by a combination of atelectasis, high oxygen concentrations, and other physiological factors.

27) Can the F-22 be retrofitted with a current oxygen system that we can have full confidence in?

27. The NESC Team believes that the current Honeywell On Board Oxygen Generator (OBOGs) is operating properly and as designed.

QFR submitted by Speier, Jackie
Subcommittee on Tactical Air and Land Forces
F-22 Pilot Physiological Issues
Thursday, September 13, 2012

31) Mr. Cragg, you said that your team's conclusions "do not represent an exhaustive review of all F-22 documentation." What other documentation would an exhaustive review include?

31. The NESC Team would define 'exhaustive review' to include review and evaluation of every single document and data source. An exhaustive review requires a significant amount of time and personnel. Based on the NESC Team's experience, the key documents necessary to understand the situation and to provide significant recommendations to the USAF were identified and reviewed.

32) Mr. Cragg, what issues should the Air Force explore in any studies of the long term impacts of the F-22's physiological strain?

32) The NESC Team believes that in some cases there could be a hypoxic-ischemic injury to certain areas of the brain that accounts for the prolonged neurocognitive symptoms experienced by some pilots. Based on early discussions with USAF medical representatives, a more objective assessment of neurocognitive function (e.g. computerized testing), as well as certain imaging studies (e.g. MRI of the brain), may be warranted in pilots who experience prolonged hypoxia-like symptoms associated with F-22 flight. Pulmonary function and diffusion testing for all F-22 pilots should also be considered. Further specifics of such testing (e.g. type and frequency) would best be addressed by technical experts in this field.

Questions for the Record
National Priorities for Solar and Space Physics Research and Applications for Space Weather Prediction
Space and Aeronautics Subcommittee Hearing
November 28, 2012

Chairman Palazzo

1. What consideration – if any – does NASA give to operational needs for space weather as decisions about the next suite of research programs are being made?

ANSWER:

NASA's Science Mission Directorate is a research-focused organization, and as such, the Heliophysics Division implements and prioritizes a research program to understand and enable space weather prediction. NASA uses the recommendations of the National Academy of Sciences' decadal surveys for guidance in planning the future of its science program and to set priorities for future missions. The focus of the Solar and Space Physics Decadal Survey released in August 2012 is on a research program for the broad range of solar and space physics.

Whenever feasible from a technical and budgetary perspective, NASA designs its research missions to support both space weather research and the National Oceanic and Atmospheric Administration's (NOAA) operational needs. NASA has included real-time data beacons on relevant heliophysics research spacecraft (e.g. Van Allen Probes, STEREO) specifically to provide real time space weather feeds to NOAA, the NASA research community and other interested parties.

NOAA, the Department of Defense (DOD), and NASA are also working on launching the Deep Space Climate Observatory (DSCOVR) in 2014. NASA provided the DSCOVR spacecraft and instruments to NOAA and is refurbishing DSCOVR under a reimbursable agreement with NOAA. DSCOVR is the most recent example of how NASA's Joint Agency Satellite Division provides expertise, on a reimbursable basis, to develop and launch instruments and satellites in support of the missions of other agencies. DSCOVR is intended as a replacement to NASA's aging Advanced Composition Explorer (ACE), launched in 1997, in making solar wind measurements at the sun-Earth L1 for geomagnetic storm warnings.

NASA will continue to work closely with NOAA (as well as other Federal agencies) on satellite development, operations, data processing, and modeling that inform and improve space weather predictions. This coordination is modeled after nationally accepted procedures in related areas (e.g., hurricane and weather forecasting) and is in the national interest to efficiently and effectively meet the growing need for the delivery of space weather information and services.

Representative Rohrabacher

1. Having conducted 74 successful missions, the NASA Explorer spacecraft carries the longest running series of scientific investigations. The solar and space physics community has done much of its best research with Explorer missions, usually within cost and schedule constraints. It's been three years since the last Medium class Explorer mission. Now, the decadal survey recommends restoring medium-class Explorer missions to enable significant scientific advances.

a. Is the availability of an affordable launch vehicle a show stopper in implementing mid-size class mission?

ANSWER: Affordability of launch vehicles is a concern across NASA's science portfolio, but is especially challenging in the case of medium-class Explorer missions due to the typical size of the satellites. Recent availability of new medium-class launch vehicles may help address this concern in the future.

b. What scientific or mission design trade-offs would be required to remain within the augmented $70 million dollars cost constraint?

ANSWER: The augmentation request as envisioned in the NRC decadal survey assumed some growth in the overall Heliophysics budget. Pending future budgets, and consistent with the decadal survey's decision rule recommendations, if the actual growth is smaller than anticipated, the additional Explorer Program augmentation would come from the LWS or STP programs and could result in a delay of one or more future strategic (LWS or STP) missions.

NASA will strive to achieve the recommended cadence between Explorer Announcements of Opportunity (AOs), although it will take a few years before this can be established.

c. What other barriers can impede NASA from implementing mid-size missions?

ANSWER: The proper phasing of available resources is always a consideration when planning for new missions.

Ranking Member Costello

1. What are the key challenges for transitioning basic solar and space physics research into tools that can be accessed by users and applied to operations?

ANSWER:

One of the most significant challenges is the effective transitioning of data, models, and applications into operations, which requires a long-term commitment, and NASA and NOAA have worked for more than two decades to improve modes of transferring research into operations. This is a multi-step process that requires agencies to work together to support all activities from the collection and interpretation of data through science missions to advance our understanding and spur model development of the dynamic space environment, to model advancement, validation and verification, and ultimately, to the effective and timely transition of these models to operations.

In response to this challenge, NASA leads multi-agency domestic and international activities that enable, support and perform the research and development to advance the state of space science and space weather modeling. NASA also conducts community-based projects to provide quantitative evaluations of the ability of research models to forecast space weather disturbance information of value to industry and government agencies, in preparation for transition to operations.

Similarly, NOAA operates a Space Weather Prediction Testbed (SWPT) to transition new research, models, and products into operations. Through the testbed, NOAA collaborates with other federal agencies and the broader research community to accelerate and improve the quantitative use of scientific research in space weather specification and prediction. NOAA coordinates with the research community and federal agencies, including NASA, on the development, validation, and testing of space weather models.

NASA's main vehicle to effectively address those aspects of space physics research that may affect life and society is through the Living With a Star (LWS) program. The LWS program supports the development of tools and/or methods that enable critically needed science advancements as well as development of comprehensive models required for a Sun to solar system forecast capability. An essential requirement of this program is that these tools/methods and "Strategic Capability" models are to be useful to the broad community and made widely available for use, analysis and validation.

All LWS products are delivered to an approved repository/server (e.g. via the Community Coordinated Modeling Center (CCMC)) for use by the scientific community and for evaluation for potential transition to operational use. The CCMC began as a multi-agency partnership focused on the creation of next generation space weather models. The goal of the CCMC is to support the research and developmental work necessary to substantially increase the present-day modeling capability for space weather purposes, and to provide models for transition to NOAA.

A study titled: "*Report of the Assessment Committee for the National Space Weather Program* (June 2006) identified several examples where programs have successfully linked research to operations, noting specifically the establishment of the CCMC at NASA, space weather centers at NOAA and within the Department of Defense, and the radiation belt modeling in the Department of Energy. The report recommended that the agencies involved should continue to support basic research modeling efforts and, if possible, provide increased resources for modeling that has space weather operational potential. The report also recommended that new resources should be made available within the National Space Weather Program agencies for transition of research models to an operational environment, including validation and revision of existing models.

A significant challenge to transitioning basic solar and space physics research into more effective tools and modeling capabilities is ensuring long-term data continuity and data availability. Ultimately, continuous observations of the space weather environment from multiple locations are required to advance our understanding of fundamental physical processes that will enable improvements in predictive models and tools.

Several studies have been conducted over the years that have identified additional challenges, in particular, organizational challenges, and issued recommendations to improve the transition process. In particular, an NRC report, *Satellite Observations of the Earth's Environment; Accelerating the Transition of Research to Operations,* (2003), identified the following issues that have hindered the research to operations process:

- Cultural differences between the research and operational communities,
- Organizational issues,
- Poor communication and coordination between the research and operational communities,
- Lack of adequate financial or educated human resources,
- Absence of effective long-range planning, and
- Inadequate scientific knowledge or technological capability.

To address these challenges, NASA and NOAA recently signed an agreement to improve coordination in transitioning space physics research into space weather operations; including expediting communications and having periodic meetings with program managers and scientists to identify lessons learned and make adjustments as needed. NASA is also committed to supporting its part of the National Space Weather Program (NSWP), a federal interagency initiative established to improve the Nation's capability to make timely and reliable predictions of significant disturbances in space weather, and to help protect critical societal infrastructure, including communication, navigation, and terrestrial meteorological spacecraft.

a. To what degree are current Federal agency activities coordinated, including funding and plans for space weather, and how effective is that coordination?

ANSWER: The National Space Weather Program (NSWP) brings together nine Federal agencies to address the nation's space weather needs. To increase communication between agencies, there are several organizations under the NSWP that are used to coordinate activities. The National Space Weather Program Council provides oversight and direction to the integrated process of setting national priorities, focusing agency efforts, and leveraging resources. The Committee for Space Weather is under the Program Council and facilitates working level relationships among the agencies by helping to coordinate activities and fostering communication and coordination between agencies.

Under the umbrella of the NSWP, NASA is working closely with its partner agencies to develop a Memorandum of Understanding that clearly delineates the roles and responsibilities of each agency in developing and executing a Unified National Space Weather Capability.

The Decadal Survey for Solar and Space Physics re-emphasizes the importance of coordination of the national efforts in support of space weather forecasting. NASA is highly supportive of increasing the effectiveness of the NSWP

2. To what extent can operational space weather monitoring be carried out by the private sector? What are the pros and cons and the risks, if any, involved in transferring part or all of this responsibility to the private sector in support of operational space weather prediction?

ANSWER: Operational space weather is the province of DOD and NOAA, and not NASA.

The analogy to tropospheric weather in this case is very strong – currently only the government has the means to build and operate the wide infrastructure of satellites and ground-based instrumentation (i.e., radars, magnetometers, and GPS receivers) that would be necessary for operational space weather. That being said, just as for tropospheric weather data, government agencies are actively exploring solutions through Requests For Information and studies of how commercial interests could meet space weather requirements through hosted payloads on commercially manifested satellite missions and potential data buys.

Some of the key considerations of any private sector source for space weather observations include the:

- Ability to provide sustained and uninterrupted observations to meet operational requirements,
- Compliance for full and open exchange and distribution of data,
- Demonstrated technical feasibility to acquire and deliver the observations and data in a reliable and timely manner, and
- Affordability of operations and cost-effectiveness to the government.

Governmental space weather resources provide data and predictions to benefit society, and NOAA provides alerts to industry and the public in advance of possible adverse conditions. However, as in tropospheric weather, there are areas where the private sector can respond to needs for customized value-added products and services to agencies and industries that are affected by space weather. Indeed, several small companies have formed over the last decade to provide targeted space weather products and solutions. The nexus between Federal agencies, academia, commercial end-users, and the burgeoning space weather industry is explored annually in the Space Weather Enterprise Forum, sponsored by NSWP and its member agencies.

Representative Edwards

1. Given the inter-agency and multidisciplinary nature of research in solar and space physics, how can affected Federal agencies and Congress monitor progress on the implementation of the recommendations of the National Research Council's decadal survey on solar and space physics?

ANSWER: NASA and its programs undergo annual assessment of their performance by independent expert review. The Heliophysics Subcommittee of the NASA Advisory Council performs this task for the Science Mission Directorate's Heliophysics Division.

Also, the National Research Council will be tasked to perform a mid-term assessment of progress implementing the recommendations from the decadal survey pursuant to Section 301(a) of the 2005 NASA Authorization Act. The results of this review are expected in 2017. Based on recent mid-term assessments of other decadal surveys, NASA anticipates that the report will detail how agency programs address the strategies, goals, and priorities in the decadal survey, outline progress towards realizing these strategies, goals, and priorities, and recommend additional actions that the agencies may wish to take in light of any changes in fiscal position or scientific discovery since the decadal survey was released.

2. To what extent does NASA's data and information on tracking solar storms get transmitted to and used by NOAA and its operations for space weather prediction?

ANSWER: All NASA Heliophysics research data is open to the public and other agencies. Solar, solar wind plasma and magnetic field-data from 1AU, L1, and near-Earth environment data are essential for both NOAA's operational space weather forecasting and NASA's research. NASA's fleet of spacecraft provides observations of solar and geophysical parameters that are incorporated into NOAA's forecasts and alerts for use by the Nation. Also, in coordination with NOAA, NASA conducts validation of candidate research models to ensure reliability and accuracy. Final testing, validation, and deployment on operational systems are the responsibility of NOAA's Space Weather Prediction Testbed.

3. What are the pros and cons of an expanded role for NASA in space environment observations, as is proposed in the solar and space physics decadal survey?

ANSWER: Decisions concerning roles and responsibilities for space environment observations are being made by the Administration in the broader context of national requirements, capabilities, and resources. In Chapter 7 of the decadal survey report, *A Vision for Space Weather and Climatology*, the committee presented a vision for a comprehensive national space weather program consisting of observations, models, and forecasting, enhanced beyond current capabilities. Given the current budget environment, it may be challenging to identify sufficient resources to fully realize that vision.

"Operating Unmanned Aircraft Systems in the National Airspace System: Assessing Research and Development Efforts to Ensure Safety"

Questions for the Record for Dr. Edgar G. Waggoner, Director, Integrated Systems Research Program Office, National Aeronautics and Space Administration

1. **Please explain how agencies such as the Federal Aviation Administration (FAA), Department of Homeland Security (DHS), National Aeronautics and Space Administration (NASA), and the Department of Defense (DoD) coordinate to identify R&D gaps.**
    a. **How do agencies decide who will fund projects to address these gaps?**

A: Several formal forums exist for coordination of agency efforts to address research gaps and to ensure no unnecessary duplication of effort. These include the Unmanned Aircraft System (UAS) Executive Committee and the Senior Steering Committee, RTCA Special Committee 203 and associated Working Groups, the Joint Planning and Development Office, and the UAS Aviation Rulemaking Committee. All of the subject Agencies are involved in each of these forums and each forum focuses on a particular aspect of UAS integration, e.g. the ExCom focuses on public UAS access. In addition, there are ad hoc on going dialogues among and between the various agencies focused on specific research activities.

In particular during FY 2011, the JPDO sponsored an effort to catalogue the UAS related activities of the subject agencies. The NextGen UAS Research, Development and Demonstration (RD&D) Roadmap was published in 2011. This report accomplished the following objectives:

- Documented an initial set of critical R&D challenges that need to be addressed to enable routine access for UAS in the NextGen NAS;
- Developed an approach to linking the R&D activities of the partner agencies with the R&D needs of the FAA to support integration of UAS in the NAS;
- Established an approach to coordinating R&D activities of the participating agencies in order to address those challenges;
- Identified relevant ongoing and planned R&D projects to serve as a baseline for the NextGen UAS RD&D Roadmap; and
- Set forth a series of next steps toward achieving a responsive, vetted Roadmap, monitoring progress, and identifying actions needed.

The UAS RDD Roadmap has assisted the JPDO partner agencies in sharing information to leverage the research investments of other agencies. Funding decisions to address UAS research gaps are made at the agency level based on priorities, capabilities and available resources.

2. **How often does the UAS Executive Committee meet to coordinate efforts?**
    a. **How many times has it met in the last year?**

A: The ExCom meets approximately quarterly. Since January 2012 the ExCom has met on the following dates: January 19, 2012, May 8, 2012, August 28, 2012, November 20, 2012, and January 9, 2013.

3. **Are there any federal agencies or organizations that are not satisfactorily fulfilling their role in addressing UAS safety concerns?**

A: The UAS RD&D Roadmap identifies responsibilities of federal agencies to conduct the R&D required to address UAS safety concerns associated with the enabling UAS routine access to the NAS. Federal agencies are fulfilling their respective roles as identified in the roadmap.

4. **Are there any organizations that should be involved that currently are not?**

A: The UAS RDD Roadmap is a comprehensive assessment of the roles of federal agencies in conducting related R&D. All agencies with a role in this effort are identified appropriately in the Roadmap.

5. **RTCA's Special Committee 203 has been working on Minimum Aviation System Performance Standards (MASPS) and Minimum Operational Performance Standards (MOPS) for unmanned aircraft. How critical are these processes in advising us what research and development work is needed?**
    a. **When are these standards likely to be finalized?**

A: The MASPS and eventually the MOPS being developed by RTCA Special Committee 203 will provide the minimum safety standards for the UAS system and two critical UAS technologies necessary for the safe introduction of UAS into the NAS for civil operations. These two critical areas for UAS civil standards are Sense and Avoid (SAA) and Control and Communications (C2). The MASPS and MOPS under development for the UAS system, SAA and C2 are very critical in advising what research and development work is needed. NASA's UAS Integration in the NAS Project continues to work closely with RTCA to support development of these standards and their associated data requirements to validate system-level performance recommendations.

The current plan within RTCA calls for the UAS System MASPS to be completed and released in May 2013. The date for the SAA and C2 MASPS is in flux.

6. **Many who follow this issue argue that a "one-size-fits-all" approach to regulation will not be effective given the wide range of systems.**
    a. **What is your recommendation for categorizing the systems? By size (i.e. weight)? Payload? Capabilities? Mission? Complexity?**

A: The categorization of the systems is the responsibility of the FAA. The UAS Integration in the NAS Project is currently evaluating the impact of size, payload, capabilities, mission, and complexity to support proposed categorization of UAS and associated operations. Research to date has identified numerous factors, including weight, complexity, and various operational capabilities that may have a significant influence on categorizing UAS. Initial work designed to determine the scope of the issue was recently published in a NASA Technical Memorandum titled "Perspectives on Unmanned Aircraft Classification for Civil Airworthiness Standards", NASA/TM–2013-217969. The outcomes of NASA research will be shared with the FAA through the end of the Project in FY 2016 to assist them with their rulemaking responsibilities.

b. How does this impact R&D investments? Do you see a greater need for R&D on smaller or larger systems?

A: NASA is conducting research on sense-and-avoid requirements applicable to UAS irrespective of size, since we do not see a difference in sense-and-avoid R&D needs in relation to large or small UAS.

With respect to airworthiness standards, the answer is not as clear. The classification research described in 6(a) indicates that further R&D investments are needed to address the unique aspects of unmanned systems that may introduce unacceptable risks, including the reliability and design assurance of equipment such as communication links for command and control, sense and avoid sensors, and ground control stations.

c. What is the status of a final rule regarding the certification and operation of small (i.e., ultralight, low-speed, short-life) UAS?

A: The FAA has not released the final small UAS rule for public comment as of this writing.

7. GAO's Dr. Dillingham testified that "(e)nsuring uninterrupted command and control for both small and large UAS remains a key obstacle for safe and routine integration into the national airspace." Dr. Dillingham's testimony also states that "UAS currently use unprotected radio spectrum and, like any other wireless technology, remain vulnerable to unintentional or intentional interference. This remains a key security and safety vulnerability..."

a. Who is responsible for ensuring the command and control and navigational links are secure, reliable, and robust?

A: In the United States, it is the responsibility of the FAA to establish the civil certification requirements for secure, reliable, and robust UAS communications. For integration in the NAS, civil UAS will need to utilize FAA certified communications equipment operating in protected safety spectrum for control communications.

To address security of the UAS control communication system, NASA is working in partnership with the FAA to analyze and develop mitigations to potential C2 security vulnerabilities to inform related FAA security requirements for civil UAS. Reliability and robustness are being addressed during the development of control communication performance requirements in RTCA SC-203, leading to control communication MASPS and MOPS. NASA has partnered with Rockwell Collins to develop a prototype UAS control communication system and perform a series of flight tests to evaluate the prototype in relevant flight environments. Results of these evaluations will be shared with the FAA.

8. Dr. Toner's statement mentioned "perception and acceptance." There are a lot of misconceptions and associated fears with regard to unmanned systems. What can be done to change that?

A: NASA's research to develop technical solutions to real challenges related to safety and security can contribute to public confidence that UAS will be at least as safe and secure as manned aircraft before they can access the National Airspace on a routine basis.

9. Please identify any projects jointly funded by FAA and NASA with any other agency, as well as the FY 2013 funding level for those projects.

A: Relative to research and development associated with integrating UAS into the NAS, NASA is cooperating on various activities across several stakeholder agencies. The majority of these cooperative activities do not require any exchange of funds. However, there are two activities where NASA is supporting the funding of specific, focused integration efforts.

The UAS Integration in the NAS Project is working closely with the FAA UAS Integration Office to deliver relevant data. The Project is currently planning to augment the FAA's contracted effort to develop the National Airspace System Enterprise Architecture (EA) at the FY 2013 funding amount of $500K. The NASA contribution will focus on integration of essential source materials (FAA UAS ConOps, FAA Roadmap for Integration of Civil UAS in the NAS, Aviation Rulemaking Committee (ARC) Implementation Plan Working Group (IPWG) Implementation plan, and JPDO Comprehensive Plan) to reflect unique aspects of UAS operations in the NAS in the NextGen Architecture.

In addition, the UAS Integration in the NAS Project is working closely with the Air Force Research Lab (AFRL) at Wright Patterson Air Force Base to coordinate on Human Factors guidelines for ground control stations (GCS). The Project is jointly funding a contract with approximately $150K to acquire software support and maintenance from the AFRL contractor for common software that both NASA and AFRL are using in our respective UAS research efforts.

10. Is it important for the FAA to regularly update its report titled "NextGen UAS Research, Development and Demonstration Roadmap?" How often would you recommend this roadmap be updated? Do you believe this document is sufficient to coordinate R&D investments? How does this document influence R&D investments at NASA?

A: As discussed previously, the NextGen UAS RD&D Roadmap is an important document that catalogued JPDO partner agency activities as they were defined in FY 2011. Additional work is ongoing through the various coordination mechanisms described above to identify gaps between current plans and assess additional R&D needs. This includes the FAA's Comprehensive Plan and the UAS Concept of Operations. Products resulting from the ongoing work need to be thoroughly assessed to understand how current investments toward UAS integration are aligned with the implementation strategy for UAS integration.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"Threats from Space: A Review of Private Sector Efforts to Track and Mitigate Asteroids and Meteors, Part II"

Questions for the Record, Dr. Donald K. Yeomans, Near-Earth Objects Program Office
Jet Propulsion Laboratory

Questions submitted by Rep. Steven Palazzo, Subcommittee on Space

1. Do we have the tools and technology necessary to detect Near Earth Objects (NEOs)? Once we identify an object, what are our means of tracking it?

   ANSWER: Since 1998, NASA has supported several ground-based optical telescope facilities for discovering and following-up NEOs. The progress for finding NEOs larger than one kilometer has been very impressive with a total discovery completion rate of more than 95 percent. Once a NEO discovery is made, a combination of professional and amateur astronomers provide the critically important follow-up optical observations that allow accurate orbits to be computed and the NEO's motion to then be accurately predicted for more than one hundred years into the future. Planetary radar observations, if available, are especially good for orbit refinement and for determining the NEO's size, shape and rotation characteristics. In addition, many amateur astronomers provide an observed time history of the NEO's ability to reflect light and hence, if these objects are irregularly shaped, these types of observations can be used to determine the rotation rate of the NEO. The Minor Planet Center (MPC) is the worldwide central node for receipt and distribution of NEO observation data. The MPC, which is funded by NASA and located at the Harvard-Smithsonian Astrophysical Observatory, collects and correlates NEO observation data from a variety of sources including amateur and professional astronomers for worldwide dissemination.

2. What categories of NEOs do we currently track, and which of these present potential cause for concern?

   ANSWER: NEOs are defined as those asteroids and comets that can approach the Earth's orbit to within about 30 million miles. In near-Earth space, asteroids outnumber comets one hundred to one. Of particular concern are the so-called potentially hazardous asteroids that can approach the Earth's orbit to within 5 million miles. Those near-Earth asteroids that are in Earth-like orbits about the sun are of most concern because they can repeatedly approach the Earth. Currently, all discovered NEOs and the subset of potentially hazardous asteroids are being tracked with ground-based optical telescopes to ensure that enough observations are available to confidently predict their orbital paths.

3. Both Dr. Holdren and Administrator Bolden testified to our committee in March that we have a long way to go to accomplish the goals established by Congress in the NASA Authorization Act of 2005 of detecting 90 percent of the NEOs with a diameter of 140 meters or greater by 2020. What are the most important steps that should be taken in the next five years to accomplish these goals?

   ANSWER: The total population of NEOs with diameters 140 meters and larger is thought to be about 20,000 and NASA-supported surveys have discovered about 25 percent of this population. It is very unlikely that the existing ground-based optical surveys will reach 90 percent completion at this size range by 2020, but NASA is evaluating systems that could make it possible by 2030 and will implement enhancements and acquire the required additional capability as soon as we are able to do so. The B612 Foundation plans for Ball Aerospace to build an infrared space-based NEO discovery telescope. This type of telescope would efficiently capture the heat (infrared re-radiated sunlight) from dark asteroids and could do so without the interruptions due to weather and daylight that affect ground-based assets. The B612 Foundation plans to philanthropically fund this effort and NASA has signed a Space Act Agreement with B612 to provide advisory information as well as spacecraft tracking and navigation support. In addition, NASA's Human Exploration and Operations Mission Directorate and Science Mission Directorate, through the Joint Robotic Precursor Activity office, are studying instrument concepts for a mission of opportunity to be hosted on a US Government or commercial spacecraft in geosynchronous orbit that will be capable of detecting and tracking asteroids in orbits very similar to Earth's; NASA released a Request for Information (RFI) in August 2012 and is studying the instrument concepts that were submitted.

4. Can you describe the potential range of damage caused by impacts from NEOs?

   ANSWER: There are vastly more small NEOs than large ones, so the most likely impact will be due to a relatively small NEO. At the small end of the NEO population size range, NEOs with diameters of 20-30 meters would be expected to cause air blasts that could cause local destruction of property and injuries (including possible fatalities) if they were to impact over populated areas. The Chelyabinsk Russia air blast of February 15, 2013, was caused by a near-Earth asteroid approximately 20 meters in size and the more powerful Tunguska blast over Russian Siberia in 1908 was due to an object of about 30-50 meters in diameter. Impacting NEOs of about 140 meters in diameter would cause regional devastation over land and possibly cause tsunamis in the more likely event they impacted into the oceans. NEOs larger than a kilometer or two would be expected to cause catastrophic effects for all nations, but especially in third world countries that lack the resources to recover from extensive crop failures and widespread infrastructure damage.

5. What are the areas in which there is a lack of knowledge or understanding of NEOs? And what barriers does the private sector face in gaining the knowledge necessary to quantify and mitigate the risk of NEO impacts?

ANSWER: In terms of the effects caused by the impacts of relatively large NEOs, the expected damage due to water impacts and the subsequent generation of tsunamis is an area of great uncertainty. Given that the Earth's surface is about two thirds covered with oceans, an ocean impact is the most likely scenario but the efficiency with which a NEO impact could cause a tsunami is not well understood.

Deflection techniques are another area in need of further study. While considerable thinking has gone into a variety of approaches (including a purposeful collision by a high speed spacecraft as well as redirection of the NEO's path by use of thrusting), more extensive analysis will be required before any of them can be considered well understood.

The success with which the current surveys have undertaken the NEO discovery searches, as well as the success of the subsequent follow-up observations and characterization studies, is largely due to the cooperative efforts of NASA and several diverse entities within the academic community. By means of NASA's annual peer-review proposal process, funding is provided to the most promising, innovative and successful NEO researchers. It is difficult to think of a more efficient process for exploiting the widespread expertise and knowledge centers that are required for addressing the complex NEO issues.

6. From where you operate, how would you describe the level of coordination between governments and outside organizations? What improvements need to be made?

   ANSWER: Under the auspices of the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS), Scientific and Technical Subcommittee, there has been an ongoing effort by the Subcommittee's NEO Working Group to provide an international framework for the detection and warning for NEOs that may represent a threat to Earth. An International Asteroid Warning Network (IAWN) has been proposed to link together the institutions that are already performing many of the proposed functions of the IAWN. Many of these functions are already being successfully carried out by NASA sponsored efforts. In addition, a Space Mission Planning Advisory Group (SMPAG) has been proposed to facilitate the gathering of necessary NEO data and to coordinate among the international entities that would likely be involved in mitigation and civil defense activities. While improvement to coordination efforts among international partners should continue, there has been an excellent start to these activities. There is reason to believe that the ongoing process will be successful in providing international guidelines and protocols that will guide a future international response to a threatening NEO.

7. What can the U.S. government do to encourage the advancement of private sector technologies that detect and track NEOs?

   ANSWER: NASA support and funding has been key to the success of the search and post-discovery follow-up and characterization observations of NEOs. Without this government support, none of this success would have been possible. As an example, NASA is working collaboratively with the privately funded B612 Foundation by providing technical assistance and operational support through a Space Act Agreement on their efforts to build a space observatory to detect 100-meter size objects and larger that could come near Earth's orbit. NASA will also provide B612 access to our Deep Space Network for telecommunications with the spacecraft for commanding and data downlink.

However, the private sector also has a very important role to play. The sophisticated telescopes, sensors, computers and other technologies used to provide and analyze the data taken on NEOs are largely a result of work done by the private sector. By providing the necessary support to NASA's NEO Observations Program, the best peer-reviewed innovative ideas are funded to discover, follow-up and physically characterize the population of NEOs. The recipients of these successful proposal grants often turn to the private sector to provide the technology to carry out their innovative ideas. This process insures a steady stream of new ideas that push the private sector providers to advance their technologies and remain competitive.

8. Should the cleanup of space debris primarily be a government issue, or is this something in which the private sector should be involved? What are the potential benefits to private organizations that become involved in the business of space-debris removal?

   ANSWER: NASA, with the help of DoD, industry, and academia, has completed an extensive review of orbital debris removal concepts. None of these concepts currently meet minimum requirements for technical maturity and affordability. However, as directed by the President's National Space Policy (2010), NASA and DoD are continuing to pursue development of early-stage technologies and techniques to mitigate and remove on-orbit debris, reduce hazards, and increase understanding of the current and future debris environment.

   Any remediation of the near-Earth space environment, if and when it happens, will necessarily involve an international effort. International treaties prevent a country from removing space objects which do not belong to it and the U.S. is responsible for less than one-third of all cataloged debris now in Earth orbit. In fact, only 6% of all objects now in low Earth orbit with a mass larger than one metric ton (these are the objects with highest potential for causing future damage) belong to the U.S.

   Early-stage technology work on debris removal technologies has begun and will likely continue in order to develop the capabilities necessary in time for potential future operations. Unlike the recycling of waste on Earth, orbital debris does not yet have an intrinsic value which would support a purely commercial undertaking. Efforts to date have been conducted by national governments, although the capabilities of the private sector could be leveraged in the future.

9. How can the U.S. government and the private sector work together to best utilize their combined resources?

   ANSWER: As noted in the response to question 7, the NASA supported NEO Observations program is already working closely with the private sector to bring into use the most sophisticated technologies. The U.S. space program has always been a driving force for private sector technology innovation.

10. What is the current system for international coordination in the event of an imminent NEO threat? What recommendations do you have to improve that system?

    ANSWER: As noted in the response to question 6, there is a successful, ongoing international process to coordinate the international response to a NEO threat, either an imminent threat or one that is years into the future.

11. Do you know of any international private organizations that are involved in NEO detection or mitigation? If so, in what ways could they contribute to the combined detection and mitigation efforts of the U.S. government and private sector and foreign governments?

    ANSWER: There are several private organizations already involved in NEO detection and mitigation in cooperation with NASA the European Space Agency, and the European Commission. For example, in the U.S., there are plans for Ball Aerospace to build an infrared space-based NEO discovery telescope for the B612 Foundation. The B612 Foundation plans to philanthropically fund this effort and NASA has signed a Space Act Agreement with B612 to provide advisory information as well as spacecraft tracking and navigation support. Dr. Ed Lu has testified concerning this concept. In Europe, the Astrium Company is working with NEOShield, currently funded by a European Commission grant, to make plans for a NEO deflection demonstration mission as well as providing technical support for a number of NEO deflection studies being undertaken by NEOShield. NASA personnel are already involved with these NEO efforts and NASA will continue to look for ways to leverage the expertise and resources of the private sector and foreign governments.

12. Have there been discussions and agreements on how much involvement in the mitigation process foreign governments are willing to provide to the U.S. government in the event of a NEO where destruction is limited to U.S. soil? How much aid is the U.S. willing to provide in a converse situation?

    ANSWER: Mitigation of an impact is an international issue and will require a cooperative response by all space-faring nations. While there have been preliminary discussions about the mitigation process among space-faring nations under the auspices of UN COPUOS, these discussions are ongoing and have not reached the level of detail required to address the issue of which nation, or nations, would be authorized to attempt a NEO deflection mission. In addition, there have not yet been substantive discussions on how the necessary resources would be provided for a NEO mitigation campaign. These issues will be addressed in future meetings of UN COPUOS or among technically capable nations.

13. How would you characterize the U.S. government's participation in UN COPUOS as it relates to asteroid detection and disaster mitigation?

ANSWER: As noted in the response to question 6, the U.S. government, with NASA in the lead, is currently participating in a productive, ongoing effort within UN COPUOS to establish an International Asteroid Warning Network (IAWN) and a Space Mission Planning Advisory Group (SMPAG). While the vast majority of the NEO discoveries, follow-up and characterization observations to date have been carried out by NASA, the European Space Agency, Japan, Russia and other nations are becoming more engaged and these cooperative efforts are being encouraged as a result of the UN COPUOS activities.

14. NEO detection and mitigation is an international concern. How are foreign governments contributing to the costs of U.S. government NEO detection technologies, and vice versa? For example, what is the U.S. government's involvement in the Near Earth Object Dynamic Site compared to that of foreign governments, and is this an adequate distribution of cost sharing and responsibility?

ANSWER: There has been no direct funding exchanged between NASA and its international partners for NEO activities, but there have been significant cooperative efforts and information exchanges between these partners. NASA is currently providing the vast majority of resources for the discovery, follow-up and physical characterization of NEOs through support of projects at US institutions. NASA-supported projects have discovered approximately 98% of all NEOs. However, the European Space Agency's (ESA) Space Situational Awareness (SSA) Program is now funding a one-meter telescope in Tenerife that provides valuable follow-up observations and ESA also completely funds the Near-Earth Object Dynamic Site (NEODyS) in Pisa, Italy. This latter site presents the results of orbital computations and, if appropriate, impact probability calculations for all discovered NEOs and it provides a valuable cross check on the parallel efforts being carried out by the NASA-supported NEO Program Office located at the Jet Propulsion Laboratory. The JPL and Pisa offices are in constant communication to verify their respective orbital and impact probability computations. In those rare cases when an object has a non-zero impact probability in the near future, JPL and Pisa cross check one another before posting results on their respective websites.

ESA's SSA program is also funding a NEO data collection activity in Germany where all the physical characteristics for known near-Earth objects are archived and made available to the international community via their website. The NEOShield effort, funded by the European Commission and noted in the response to question 11, is also active in studying the various techniques that could be used to deflect or disrupt a NEO on an Earth threatening trajectory. Japan's very successful Hayabusa mission achieved a rendezvous with near-Earth object Itokawa in 2005 and returned a small sample from the surface of this object in June 2010. NASA provided some spacecraft tracking and spacecraft navigation support and several U.S. members of the scientific community participated on the Hayabusa Science Team. Japan is currently planning a Hayabusa 2 mission to another near-Earth asteroid and there will likely be continued cooperative efforts with NASA participation. These Hayabusa NEO rendezvous missions, along with NASA's rendezvous mission to near-Earth asteroid Eros in 2000, the rendezvous and sample return mission OSIRIS-REx, and the planned first-ever mission to identify, capture, and redirect an asteroid into orbit around the Moon for future astronaut rendezvous and sampling are, and will be, important sources for the detailed understanding of near-Earth object structures and compositions. Russia is also undertaking studies to better understand the optimal techniques for deflecting near- Earth asteroids.

15. Considering the low probability of a devastating NEO impact, are detection and mitigation projects worth their high costs?

    ANSWER: An early discovery of an Earth-threatening NEO would allow the time to safely deflect it with existing technologies. As the search for NEOs continues, and more and more of them are discovered and tracked one hundred or more years into the future, their risks to Earth can be evaluated. More than 95 percent of the largest NEOs (1 kilometer and larger) have already been discovered for a total cost of less than $70 million spread over 15 years, and it is reassuring to know that none represent a serious impact threat in the next one hundred years. Despite the low probability of a devastating NEO impact, it seems prudent to continue to invest in strategies for early warning and mitigation.

16. The President's Budget places NASA's asteroid strategy as a more visible component of the agency's mission, particularly in regard to human spaceflight. The agency is proposing combining agency efforts to ultimately have a human mission planned for 2021. What are your thoughts about the Administration's proposal? Specifically, can the various components NASA says it needs for a human mission benefit the overall goals we are discussing here today?

    ANSWER: The FY 2014 President's budget contains funding to accelerate technology development in areas important in their own ways for exploration, including advanced solar propulsion. It also provides funds to begin planning for an Asteroid Redirect Mission (ARM) that would utilize advanced solar propulsion technologies to rendezvous with, and redirect, a small NEO (about 7 meters in diameter) and bring it back into a stable orbit in the lunar vicinity for sampling by astronauts. While the ARM planning is not driven by science objectives, the necessary search for a suitable target asteroid would certainly provide an increase in the discovery rate of NEOs along with a concomitant increase in the characterization of this population. Since the stringent requirements for a suitable ARM target body dictate that these targets be in rather Earth-like orbits, this population of Earth's closest celestial neighbors would be better characterized than is currently the case. Those NEOs that are most easily reached by spacecraft, or most suitable for round trip human exploration, are the same objects that represent the greatest likelihood of striking Earth. A better understanding of this population would benefit both planetary science and planetary defense.

Questions from Ranking Member Eddie Bernice Johnson to Dr. Yeomans

1. This Committee is working on reauthorizing NASA for FY 2014 and beyond. In your view, what priorities with regard to NEOs do we need to address in legislation? How do we ensure that private-sector and international initiatives are effectively leveraged and integrated into a global response?

   ANSWER: To best understand and characterize specific NEOs, early detection is key. The approach within the NEO Program in the President's FY14 budget request is to expand the existing NEO detection and characterization activities. This includes making available more time on existing ground-based observatories capable of detecting or characterizing NEOs, such as Pan-STARRS or the Space Surveillance Telescope (SST).

   Also, the President's budget contains funding for an Asteroid Redirect Mission (ARM) that would utilize advanced solar propulsion technologies to rendezvous with, and redirect, a small NEO (about 7 meters in diameter) and bring it back into a stable orbit in the lunar vicinity for possible study by astronauts. While the ARM planning is not driven by science objectives, the necessary search for a suitable target asteroid would certainly provide an increase in the discovery rate of NEOs along with a simultaneous increase in the characterization of this population. Since the stringent requirements for a suitable ARM target body dictate that these targets be in rather Earth-like orbits, this population of Earth's closest celestial neighbors would be better characterized than is currently the case. A better understanding of this population would benefit both planetary science and planetary defense.

   Deflection techniques are another area in need of further study. While considerable thinking has gone into a variety of approaches (including a purposeful collision by a high speed spacecraft as well as redirection of the NEO's path by use of thrusting), more extensive analysis will be required before any of them can be considered well understood. The on-going international cooperative mission studies and NEO data gathering are effective ways to leverage the resources and expertise in the international community.

2. What are the risks, if any, of relying on non-government organizations to provide data needed to meet a congressional mandate? If such non-governmental capabilities are delayed or become unavailable, what options would the government have to obtain the needed data?

   ANSWER: NASA has established a Space Act Agreement with the B612 Foundation on their Sentinel Project to provide some technical advice, spacecraft tracking and navigation services as well as processing the observations through the existing NASA-supported Minor Planet Center and NASA's Near-Earth Object Program Office. While NASA fully supports the Sentinel activity, NASA continues to monitor its progress and assess its viability, and more robust alternative options are being studied. In addition, NASA's Human Exploration and Operations Mission Directorate (HEOMD) and Science Mission Directorate (SMD), through the Joint Robotic Precursor Activity (JRPA) office, are studying instrument concepts for a mission of opportunity to be hosted on a US Government or commercial spacecraft in geosynchronous orbit that will be capable of detecting and tracking asteroids in orbits very similar to Earth's; NASA released a Request for Information (RFI) in August 2012 and is studying the instrument concepts that were submitted. Another alternative would be to place a space-based infrared telescope at a location about one million miles on the sunward side of the Earth at the so-called L1 point. This would allow continuous observations and image downlinks of near-Earth objects down to sizes below 100 meters. NASA is committed to satisfying the Congressional mandate to find and track 90% of the near–Earth asteroids larger than 140 meters that are Earth impact hazards.

3. What are the key challenges to meeting Congressional direction on surveying, detecting, and characterizing near-Earth objects equal to or greater than 140 meters in diameter by 2020? In your opinion, is this a technological issue or are budgetary resources the key pacing item?

   ANSWER: The key challenge in meeting the Congressional direction outlined in the 2005 NASA Authorization Act is to efficiently detect the remaining thousands of undiscovered 140 meter and larger sized NEOs within the next several years.

   While ground-based surveys are making excellent progress increasing the discovery rate, it will require a space-based infrared NEO telescope to significantly increase the current detection rate. The expertise and technology exist to build, launch and operate an infrared telescope, located either in a heliocentric orbit at a distance similar to that of the planet Venus or located on the Earth-Sun line about one million miles sunward of Earth (at the so-called first Lagrange point, or L1). The B612 Foundation has announced plans to philanthropically fund an effort to operate an infrared telescope in a Venus-like orbit. NASA has signed a Space Act Agreement with B612 to provide advisory information as well as spacecraft tracking and navigation support. Dr. Ed Lu has testified concerning this concept. NASA has also funded an advanced infrared detector development that could be employed on an infrared telescope operating at the Sun-Earth L1 position. In addition, NASA is advancing work on instrument concepts for a mission of opportunity to be hosted on a US Government or commercial spacecraft in geosynchronous orbit that will be capable of detecting and tracking asteroids in orbits very similar to Earth's. NASA is also evaluating reactivating our NEOWISE activity, a very successful use of an Earth-orbiting, Wide-field Infrared Survey Explorer (WISE) space telescope that was used in 2010-2011 to find and physically characterize near-Earth objects.

4. What are the challenges involved in assimilating NEO detection and characterization input from multiple observing platforms? How could this be done?

   ANSWER: NEO detection, follow-up observations and physical characterization measurements are already being carried out at multiple international observatories and coordinated within a few NASA and ESA supported facilities. The discovery and follow-up observations are forwarded to the international central clearing house at the NASA-supported Minor Planet Center (MPC) and from there these observation are forwarded to both the computational centers at the Jet Propulsion Laboratory (JPL) and the NEODyS facility in Pisa, Italy. This latter facility is supported by the European Space Agency's Space Situational Awareness program. In turn, the MPC, JPL and the NEODyS facilities provide observing predictions (ephemerides) to the observer community. At JPL, observing position, velocity and range predictions are provided to observers at the planetary radar facilities at Goldstone's 70-meter antenna in southern California and to observers at the 305-meter antenna located in Arecibo, Puerto Rico. JPL's automated Horizons on-line ephemeris service provides more than 80,000 ephemeris products daily to the international research communities. While challenges will arise for assimilating NEO detection and characterization inputs from multiple ground-based and space-based platforms, the successful track record for ground-based observing platforms suggests these challenges will be met in a straightforward manner.

5. To what extent do international space agencies or international facilities contribute to NASA's NEO survey and/or a worldwide effort of surveying, tracking, and characterizing potentially hazardous near-Earth objects? How effective is communication and data-sharing on near-Earth object tracking among nations? What is the degree of international involvement in studying deflection options for NEOs? What more could be done?

   ANSWER: The international community of NEO researchers is well coordinated and has been working cooperatively for several years. The international communication and data sharing channels are operating well.

   While NASA has been responsible for almost all of the NEO discoveries and the efforts to physically characterize a representative sample of these objects, there has been recent progress in NEO research in the international community as well. In particular, there are ongoing efforts, funded by the European Space Agency, to collect and archive the existing physical data on NEOs, to compute orbits and predict close Earth approaches in parallel with similar efforts at the Jet Propulsion Laboratory and to provide the critically important post-discovery follow-up observations that allow accurate orbits to be determined for recently discovered NEOs. Under a grant provided by the European Commission, the NEOShield program is carrying out studies to determine the optimal techniques for NEO deflection and as well as outlining plans for an asteroid deflection demonstration mission. The Japanese Aerospace Exploration Agency (JAXA) has successfully carried out the rendezvous mission Hayabusa to near-Earth asteroid Itokawa and returned a small sample to Earth in June 2010 so that the international community can carry out detailed analyses to determine the elemental composition of this NEO. JAXA is also making plans for a Hayabusa 2 mission to rendezvous with, and return a sample from, another near-Earth asteroid. U.S. scientists are interacting or participating with the ESA, European Commission and JAXA activities. In addition, Russian scientists have carried out a number of studies to investigate options for deflecting NEOs.

   All international discovery and follow-up observations as well as preliminary orbital computations for NEOs are carried out at the NASA-sponsored Minor Planet Center (MPC) in Cambridge Massachusetts. The MPC is the recognized international clearinghouse for these data and its work is carried out under the auspices of the International Astronomical Union. The MPC collects and archives these data, notifies the international observing community which objects need follow-up observations and is the first agency to announce the possibility of short term Earth close approaches or impacts. The MPC has been in continuous operation since 1947 and is instrumental in the effective and timely communication of NEO discoveries, coming close Earth approaches and future NEO observing opportunities.

Because the first step in deflecting hazardous NEOs is to find them early enough to allow a successful mitigation campaign, the emphasis to date has appropriately been on the NEO search, follow-up and characterization efforts. Nevertheless, there have been several studies carried out to investigate the optimal techniques and mission designs to deflect NEOs. For example, JPL personnel carried out a 2012 study to better understand the viable mission options for deflecting a NEO designated 2011 AG5 in the unlikely event that this object's non-zero impact probability in 2040 remained a possibility. While recent observations of this object allowed its orbit to be refined to such an extent that the 2040 Earth impact possibility was ruled out, the study outlined the steps necessary for planning, designing and launching an impacting spacecraft to deflect a hazardous NEO.

Finally, under the auspices of the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS), Scientific and Technical Subcommittee, there has been an ongoing effort by the Subcommittee's NEO Working Group to provide an international framework for the detection and warning for NEOs that may represent a threat to Earth. An International Asteroid Warning Network (IAWN) has been proposed to link together the institutions that are already performing many of the proposed functions of the IAWN. Many of these functions are already being successfully carried out by NASA sponsored efforts. In addition, a Space Mission Planning Advisory Group (SMPAG) has been proposed to facilitate the gathering of necessary NEO data and to coordinate among the international entities that would likely be involved in mitigation and civil defense activities. While improvement to coordination efforts among international partners should continue, there has been an excellent start to these activities. There is reason to believe that the ongoing process will be successful in providing international guidelines and protocols that will guide a future international response to a threatening NEO.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"Threats from Space: A Review of Private Sector Efforts to Track and Mitigate Asteroids and Meteors, Part II"

Questions for the Record, Dr. Donald K. Yeomans, Near-Earth Objects Program Office
Jet Propulsion Laboratory

Questions submitted by Rep. Steve Stockman

- What are the key technology demonstrations that would need to be conducted for deflecting asteroids?

  ANSWER: Deflection techniques are an area in need of further study. While considerable thinking has gone into a variety of approaches, including a purposeful collision by a high speed spacecraft as well as redirection of the NEO's path by use of thrusting. The proposed Asteroid Redirect Mission, which intends to use advanced solar electric propulsion technologies to rendezvous with and redirect a small NEO, could also inform potential asteroid deflection techniques. Regardless the chosen method, more extensive analysis will be required before any of them can be considered well understood.

- What is the state of the readiness of the technology for the various methods of deflecting asteroids?

  ANSWER: The most effective approach to mitigation of a potential asteroid impact threat is highly dependent on the scenario. Near-term impact of an asteroid tens of meters in diameter requires a significantly different approach than the threat of a larger object that might impact decades in the future. The orbit parameters of the potential impactor are also a significant factor in determining an effective mitigation strategy. Therefore, a "toolkit" of mitigation approaches needs to be developed at the conceptual level to address the range of potential impact threats. While considerable thinking has gone into a variety of approaches (including a purposeful collision by a high speed spacecraft as well as redirection of the NEO's path by use of thrusters), more extensive analysis will be required before any of them can be considered well understood. As a next step, in FY 2014, NASA's Office of the Chief Technologist plans to develop a roadmap of mitigation technologies.

- What would be the effective range (in time/distance) of applicability of each different method of deflection?

  ANSWER: The most effective deflection methods are not carried out when an impacting object is on its final trajectory with only a few days or even weeks before impact, but rather several years and many orbits of the Sun away from the predicted time of impact. The most important element of any deflection method is to find the hazardous object as early as possible. Each NEO deflection campaign would depend upon several variables including the size, mass, rotation and composition of the NEO as well as the time available before impact.

QUESTIONS SUBMITTED BY SENATOR FEINSTEIN

MARS EXPLORATION

Question. The Curiosity Rover landing and the astonishing images coming back from Mars have generated enormous public support for Mars exploration. The scientific community broadly supports the next Mars mission as well, as demonstrated by its top ranking in the National Research Council's Decadal Survey. Moreover, Congress gave clear direction to prioritize this program in Fiscal Year 2013, reversing the severe cuts proposed in the President's Budget. Despite Congressional, scientific, and public support, the Budget proposal for Planetary Science and Mars this year looks remarkably similar to last year. Why has the Administration chosen to scale back this critical funding so significantly?

Answer. The Mars 2020 rover mission continues the pursuit of the Mars Exploration Program's science theme of "*Seeking the Signs of Life.*" The mission objectives are to explore an astrobiologically relevant ancient environment on Mars and to search for potential biosignatures within that geological environment. This mission will enable concrete progress toward eventual return to Earth of carefully selected materials, thereby satisfying NRC Planetary Decadal Survey science recommendations, and it will provide opportunities for accommodation of contributed Human Exploration & Operations Mission Directorate (HEOMD) payload element(s), technology infusion, and international participation.

Currently, a Science Definition Team is working to outline the science measurements required to meet the above objectives for Mars 2020, and the project team is assessing the engineering requirements and defining the overall mission concept, including the use of residual flight hardware and expertise from the Mars Science Laboratory (MSL) mission. As the mission concept is further developed, we will proceed to a Mission Concept Review in the fall of 2013, which will be followed by an openly competed payload Announcement of Opportunity.

At the time of the FY 2014 budget formulation, NASA was in the early stages of defining the 2020 mission, and significant uncertainties remain as to the phasing of the mission's overall budget pending the results of the Science Definition Team and the upcoming Mission Concept Review later this year. The FY 2015 budget formulation process will provide the opportunity to assess the budget profile for the Mars 2020 mission based on this better understanding of mission requirements.

Question. The Mars Program funding profile in the budget recommends funding increases in Fiscal Years 2017 and 2018. But the increases would only occur after severe lean years in fiscal years 14, 15 and 16. How will NASA maintain its experienced and successful "entry, descent and landing" team in the coming years with this budget?

Answer. NASA's Science Mission Directorate recognizes that making steady progress towards the Mars 2020 mission launch will be critical to retaining the core capabilities in MSL-based Sky-Crane entry, descent and landing and

Curiosity-class rover engineering systems. Currently, members of the Curiosity EDL team are engaged in reconstruction and analysis of data taken during Curiosity's landing to provide critical information for future Mars landers and rovers. Some members of the team are also supporting other Agency efforts in the immediate term. The ongoing concept definition for Mars 2020 will provide input to the FY 2015 budget process, including the workforce requirements.

Question. In an effort to save money, the re-scoped Mars mission for 2020 called for a rover that has a virtually identical design as Curiosity, but carries different scientific instruments. This was done to streamline costs and maintain an early launch date within a limited budget. But, it is my understanding that the budget will not allow the suppliers and staff who worked on Curiosity to begin work on the new vehicle for several years. Why have you chosen to delay rover construction even though the staff and suppliers are available to do the work today?

Answer. At the time of the FY 2014 budget formulation, NASA was in the early stages of defining the 2020 mission, and significant uncertainties remain as to the phasing of the mission's overall budget pending the results of the Science Definition Team and the upcoming Mission Concept Review this year. Currently, the team is preparing for acquisition of key long-lead parts. The FY 2015 budget formulation process will provide the opportunity to assess the budget profile for the Mars 2020 mission based on this better understanding of mission requirements.

COMMERCIAL CREW

Question. The President's Budget proposes a significant increase for the Commercial Crew program — a 36 percent increase over the level provided in the FY 2013 Omnibus. Can you explain why the budget proposal includes this increase? Will it allow for a meaningful competition to occur among private entities seeking to enter the space launch business?

Answer. The President's FY 2014 Budget Request would restore the Commercial Crew Program funding to the level requested in previous budgets to bring an American commercial system to operational use as quickly as possible (NASA is estimating by 2017, though the companies have indicated that they could do it sooner). Through the Commercial Crew Integrated Capability (CCiCap) effort, NASA is funding three companies in an attempt to promote meaningful competition in the development of their crew transportation systems, and reduce the eventual per-seat price of commercial crew transportation and rescue services.

SPACE LAUNCH PROCUREMENT

Question. Both NASA and the Department of Defense (DoD) require affordable access to space, but the agencies have taken different approaches on how to achieve that goal. NASA has effectively used competition and fixed price contracts to drive down costs, while the DoD is primarily relying on buying in bulk, what they call a "block-buy" strategy. From your experience, how has competition and fixed-price contracting benefited the Agency in its space launch procurement, both in terms of cost savings and mission success?

Answer. When appropriate, NASA has successfully utilized competition and fixed price contracting to drive down costs without compromising mission success. Specific examples include NASA Launch Service (NLS) and the Tracking and Data Relay Satellite System (TDRSS) contracts.

NASA pursues a "mixed fleet" approach to assure its access to space by using a competitive strategy across a variety of commercial launch services to support the small, medium and intermediate range. Historically, NASA has benefited significantly from competition and fixed-price contracting in the intermediate class launch services. However, one must be flexible and adjust the strategy to fit market conditions. In the past, we have also benefitted from a large block buy in the medium class when no competition existed or was forecasted. More recently, NASA was able to achieve good pricing for its medium class missions by utilizing competition. With the recent success of emerging launch service providers, NASA can regain the benefit from competition in the intermediate class and maintain competition in the medium class. The small class has only witnessed minimal competitive scenarios so far; however the fixed-price contracting has helped keep costs in check. As to mission success, a technical evaluation of capabilities and past performance of the commercial providers is evaluated as part of any competition, along with cost and other variables in order to determine a "best value" selection to meet NASA's needs and the mission's risk posture. Since NASA's Launch Services Program creation in 1998, mission success in the medium and intermediate class launch services has thus far been 100 percent successful. Up until the two Taurus XL launch failures in 2009 and 2011, mission success in the small class had also been 100 percent successful. Launch is still a very challenging engineering endeavor, and no system will be able to maintain a 100 percent success record. Maintaining competition and using the NASA Launch Service Firm Fixed Priced contract structure and terms is critical to ensuring that NASA receives the best value for its launch services.

In addition to these programs, NASA believes that maintaining competition for the Commercial Crew program is critical to ensuring that NASA and the nation receive the best value for future U.S.-based crew transportation to ISS. Competition also incentivizes the companies to invest their own funds and share in the development costs of their Crew Transportation System. Having industry share in the cost of development and selling seats to other customers in addition to NASA will likely decrease NASA's costs for crew transportation services in both the short and long-term. The competitive environment provides strong incentive for the companies to align with NASA's certification requirements in order to remain competitive in the future certification and services phases. Having multiple companies competing against each other will help ensure the safest and most cost effective system possible for the Government.

SPACE TECHNOLOGY

Question. The budget proposes creating a new Space Technology directorate, and funding it at $742M in FY 2014. Can you explain how the program and the new structure will improve our ability to protect astronauts on long-term deep-space missions? How will the work being done interact with the ongoing work within the Science mission directorate?

Answer. The Space Technology Mission Directorate (STMD) was formally established in February 2013 to bring about innovative solutions that dramatically improve technological capabilities for NASA and the Nation. This new mission directorate has management and budget authority of the Space Technology programs, which are performed by all 10 NASA Centers. It focuses on project execution and technology infusion into the Agency's exploration and science mission needs, taking a customer driven approach to prove capabilities needed for future NASA missions and the national aerospace community.

Using a broad investment strategy, NASA's Space Technology investments address the identified range of technology areas found in NASA's Space Technology Roadmaps as prioritized by the National Research Council. The Space Technology portfolio supports a combination of early stage conceptual studies, discovering entirely new technologies; determining technology feasibility through rapid competitive development and ground-based testing; and flight demonstrations in relevant environments, completing the final step to mission infusion.

To achieve our human spaceflight goals, there are many technological barriers that must be overcome to allow humans to travel further from Earth. HEOMD conducts architecture studies (e.g. Human Exploration Framework Team (HEFT), Human Spaceflight Architecture Team (HAT)), which identifies needed technologies, as well as their timeline to perform future deep space human exploration missions. Exploration Technology Development (ETD) within the Space Technology budget is targeted specifically at human exploration technology needs. This includes the development and demonstration of high power solar electric propulsion (SEP) capabilities, scalable to handle power and thrust levels needed for deep space human exploration missions. High power SEP is considered essential to affordably performing human exploration missions to distant destinations such as Mars. In addition, NASA is investing in technologies that will allow for the in-space storage and transfer of cryogenic fuels to meet the needs for future propulsion stages to move crew from Low Earth Orbit to a variety of destinations. Providing such long duration storage and transfer of propellants is considered essential for any human exploration missions beyond the earth-moon system. Finally, Space Technology within the ETD program area is maturing a suite of critical technologies identified by the HEFT. HAT and other human exploration studies. Technologies within the portfolio include: life support components for next generation space suits and habitats, in-situ resource utilization components to detect water and produce oxygen from carbon dioxide (considered essential to produce ascent vehicle propellants for a human Mars mission), advanced batteries to support long spacewalks, high efficiency fuel cells that require no consumables and can be recharged for reuse during long duration missions, radiation modeling methods to improve the lead time for solar events, autonomous systems that will permit astronauts to efficiently operate independent of ground controllers, and robotic systems that can work in close proximity to humans, off-loading maintenance and operational tasks from astronaut duty cycles.

For science, this includes developing technologies that can increase communications bandwidth so NASA is able to receive more data from spacecraft studying the far corners of our solar system. In addition, we are developing technologies to improve accuracy of navigation systems and improve the longevity and efficiency of spacecraft power systems. Space Technology is developing and will demonstrate a Solar sail seven times larger than any solar sail tested in space to date, which has tremendous potential for future heliophysics missions. STMD also continues to support future planetary science missions through investments in advanced entry descent and landing (EDL) technologies, such as a new 33 meter ring sail parachute and supersonic inflatable aerodynamic decelerators to improve upon the landed mass and landing accuracy demonstrated by Curiosity. These new chutes and other supersonic decelerator technologies such as STMD investments in supersonic retro propulsion are necessary for human missions to the Mars surface. EDL technology investments also include inflatable and mechanical deployable heat shields applicable for robotic missions to multiple planets, as well as human missions to Mars. STMD is also investing in a new class of woven-carbon thermal protection materials permitting new missions to Venus as well as the other planets. The STMD is working with SMD to coordinate technology investments in nuclear systems and chronographs/starshades needed for next generation astrophysics observatories, with a goal of a space asset capable of detecting the atmospheric content and potential presence of life of earth-like planets orbiting distant stars. In addition, STMD conducts annual small spacecraft demonstrations which tests subsystems that enable small spacecraft as well providing for an affordable test platform for future larger systems.

QUESTIONS SUBMITTED BY SENATOR SHELBY

SPACE ACT AGREEMENTS/FAR CONTRACTS

Question. Please provide a detailed list of NASA authorities granted by the Space Act Agreements for the Commercial Crew program. In particular, what unilateral authority to investigate participants, their activities and their books (specifically related to commercial crew activities) does the agreement grant NASA and what must NASA have permission from the contractor to access?

Answer. Under the CCiCap SAAs, NASA has the authority to request any data first produced by the Partner under the agreement for the purpose of evaluating the Partner's performance of its milestones. NASA has the authority to review the Partner's records to determine if any inventions were made under the agreement and whether the Partner has complied with the requirements of the agreement relative to reporting of inventions. The Partner is also required to report any mishap, and NASA has the authority to request any reports and data resulting from the Partner's mishap investigation.

Question. Does NASA have the authority to investigate the Commercial Resupply Service flights, which to date, have had multiple incidents on ascent and at least once at landing, and if not, what is required for NASA to gain insight into these and any future mission irregularities?

Answer. The Commercial Resupply Services (CRS) contractor has the lead for anomaly resolution for phases of the mission during which they have responsibility (as was the case for the recent Dragon thruster anomaly which was successfully resolved). However, under the terms of the CRS contract, NASA officials are kept well apprised of the nature and progress of these activities, and NASA technical personnel may participate in the contractor's investigation and resolution of anomalies. SpaceX provided all relevant data necessary, including anomaly resolution information, to perform the rendezvous and berthing of the Dragon to the ISS.

Question. Can NASA provide the timing for conversion to FAR based contracts for the certification of commercial capabilities and procurement of crew transportation services? Does NASA intend to sign further Space Act Agreements, or modifications to current agreements that are currently signed, for commercial crew prior to implementing FAR based contracts?

Answer. NASA's contracting effort for the certification of commercial crew transportation services began with the first contract phase, the Certification Products Contracts (CPC). CPC was awarded to three companies on December 19, 2012. Under these FAR based contracts, the selected contractors are developing products that will lead to the certification of their integrated commercial crew transportation systems. Advances made by these American companies during CPC are advancing the process of ensuring integrated crew transportation systems that will meet agency safety requirements and standards to launch American astronauts to the International

Space Station from the United States, ending the Agency's reliance on Russia for these transportation services.

The CPC contractors are:

- The Boeing Company, Houston, Tex.;
- Sierra Nevada Corporation Space System, Louisville, Colo.; and,
- Space Exploration Technologies Corp., Hawthorne, Calif.

The procurement planning for the second phase of the FAR-based certification contracts, known as the Commercial Crew Transportation Capability (CCtCap) procurement, has begun and will result in a separate competition. CCtCap award(s) are planned for the summer of 2014.

NASA does not currently intend to conduct additional competitions for Space Act Agreements to support commercial crew development. As companies mature their designs, NASA will determine whether exercising optional milestones is in the best interest of the Government.

COTS PROGRAM

Question. During the COTS program, the Space Act Agreements frontloaded the funding milestones so that nearly 90 percent of the funds were provided to companies before a single launch occurred in order to ensure the capability was developed and available when needed.

Given that significant federal investment has already been made in a commercial capability which is a "launching point" for much of the commercial crew capability, has NASA considered backloaded payments for commercial crew in an effort to push for a greater private investment in the capability and greater accountability with respect to achieving milestones, imbedding safety tests and meeting schedule requirements?

Answer. NASA performs a full and comprehensive analysis of the milestones, deliverables, and payment options for all procurements and/or agreements. All types of payment options are considered and the specific type is chosen to best meet the objectives of the activity.

With respect to the COTS and Commercial Crew funded Space Act Agreements, the milestones and the amount of the milestones were proposed by industry and NASA reviewed them for appropriateness and the extent to which they met the objectives of the Announcement for Proposals.

COMPETITION

Question. The commercial crew program has been characterized as a competition. However, NASA has provided $1.5 billion in incentivized grants to three companies for the development of crew launch vehicles. This does not sound like a traditional competition where multiple companies compete and one wins. This sounds like a grant program that makes everyone a winner -- except perhaps the taxpayer who is paying multiple times for the same product.

Could you explain why NASA is calling the commercial crew program a competition and how this approach will save taxpayer dollars if NASA is paying to develop multiple launch vehicles?

Answer: NASA characterizes the Commercial Crew Program as competitive because industry competes for awards under the program. Multiple companies competed for funded Commercial Crew Development (CCDev) and Commercial Crew Integrated Capability (CCiCap) awards and did not receive them, so the characterization of everyone being a winner is incorrect. NASA has leveraged the benefits of competition among companies for awards through the conduct of multiple competitions thereby requiring the companies to provide best value during each phase of the activity.

Maintaining a competitive environment for the Commercial Crew Program is critical to ensuring that NASA and the nation receive the best value for future U.S.-based crew transportation to ISS. In addition, continued competition among providers incentivizes the companies to expand their commercial market base by selling services to any other customers to maintain reasonable prices. Continued competition among providers also incentivizes the companies to invest their own funds and share in the development costs of their systems. Competition is also the fundamental basis for establishing fair and reasonable pricing for all requirements. Having industry share in the cost of development and selling seats to other customers in addition to NASA will likely decrease NASA's costs for crew transportation services in both the short and long-term.

The establishment of this competitive environment provides strong incentive for the companies to align with NASA's certification requirements in order to remain competitive in the future certification and services phases. Having multiple companies competing against each other will help ensure the safest and most cost effective system possible for the Government.

NASA is not paying multiple times for the same product. Each commercial crew industry participant is proposing a unique crew transportation system (even when using the same launch vehicle) and NASA's investments are helping to develop those unique systems. The benefits of this approach can be seen in the commercial cargo program which should soon have demonstrated two different U.S. cargo systems for ISS logistics. NASA refers to this as "dissimilar redundancy" and it allows NASA to be able to absorb a failure of any one system without a major impact to on-orbit operations. Additionally, the technology development that has been achieved by all the Commercial Crew companies will benefit other space based activities and expand the U.S. space industrial base.

Question. Please elaborate how the timing of NASA investment in commercial crew, and the spreading of that investment across multiple companies results in efficient use of federal funding and optimizes private investment. Also provide any studies either done independently or by NASA that support the implementation of commercial crew.

Answer. The President's FY 2014 Budget Request will enable the re-establishment of U.S. human access to space by 2017. Through the Commercial Crew Program, NASA is funding multiple industry concepts in an attempt to promote meaningful competition among providers in the development of their crew transportation systems, and reduce the eventual per-seat price of commercial crew transportation and rescue services. Please see response to Question above.

The most prominent study supporting the implementation of commercial crew is the Final Report of the Review of U.S. Human Spaceflight Plans Committee published in 2009 and available online at http://www.nasa.gov/pdf/396093main_HSF_Cmte_FinalReport.pdf.

Question. If none of the current contractors for commercial crew vehicle development are able to meet NASA's requirements for safely delivering crew to the international space station, will NASA choose to continue the program, as they did with COTS, at whatever the cost or delays in schedule may be?

Answer. It is NASA's intention to use U.S. commercial industry to provide crew transportation and rescue services to the International Space Station (ISS). The Agency has made its crew safety requirements available, and is confident that one or more potential vendors will be able to develop safe crew transportation services by 2017, contingent upon the availability of appropriated funds and technical progress.

Question. Have any of the commercial crew participants shown to NASA that their business will go forward, regardless of receiving NASA funding or guaranteed flights to the international space station?

Answer. NASA has not requested a guarantee from our industry partners for their businesses to go forward without NASA funding. However, each company has a unique view of the market for human space transportation and unique business cases for completing the development of their systems.

As part of the Commercial Crew Program Industry Touchpoint held in April 2013 in Colorado Springs, NASA did request industry input regarding post-certification missions to the ISS. This information is being used by the NASA in the preparation of the Request for Proposals for the Phase 2 Certification contract.

COMMERCIAL CREW VERSUS INTERNATIONAL PARTNERS

Question. Will NASA continue payments to the Russians as a back-up to commercial crew services and for how many months, or years after commercial crew services become regularly available?

Answer. NASA recently signed a modification to its contract with the Russian Federal Space Agency (Roscosmos) for full crew transportation services to the ISS in 2016 with return and rescue services extending through June 2017. NASA is facilitating development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable and cost-effective access to and from the space station and low-Earth orbit beginning in 2017. NASA is committed to launching U.S. astronauts aboard domestic spacecraft as soon as possible.

Question. NASA's commercial crew program projects that a vehicle will be ready to launch in 2017. However, given the schedule delays in the commercial cargo program, it is likely that the crew program will experience delays as well. If that is the case, I question the value of moving forward with an extremely costly commercial crew program when the Space Station is currently slated for decommissioning in 2020.

Has NASA done a cost-benefit analysis comparing the cost of developing a commercial crew capability with the cost of using our international partners to provide those same flights given that there will likely be a limited number of flights to the Space Station?

Answer. NASA has not performed a cost-benefit analysis comparing the cost of developing a commercial crew capability with the cost of using foreign systems. NASA's commercial crew partners have not formally established final pricing for ISS services missions. In keeping with the 2010 NASA Authorization Act, NASA believes U.S. human access to space is a critical capability for the nation and that commercial crew capabilities are a key means to achieve this goal. The lifetime extension data that NASA and the ISS Partnership have reviewed to date indicates that the ISS could operate until at least 2028.

Question. Is this the best way for NASA to spend scarce taxpayer dollars when the capability already exists and there are so many other endeavors in which to invest?

Answer. Yes. The capability does not already exist within the United States and NASA is committed to launching U.S. astronauts aboard domestic spacecraft as soon as possible. Like the COTS program, the commercial crew program appears to date to be a cost-effective means of developing U.S. space capabilities. Full funding of the Administration's FY 2014 budget request is critical to making these domestic capabilities possible by 2017. The commercial crew industry partners have indicated that they believe they could be ready prior to that date. But, NASA has included some schedule margin because human spaceflight development efforts have historically been challenging. Thus, NASA believes 2017 is a reasonable estimate for the availability of U.S. commercial crew services, pending adequate funding and technical progress.

Question. At what point in the development of US based crew vehicles will NASA stop negotiating future flights with the Russians and is there a planned overlap in case the commercial vehicles are not ready in time?

Answer. NASA will monitor the development of commercial crew vehicles closely. It is important to note that the Russians require approximately three years of lead time to manufacture a new Soyuz spacecraft, so the Agency has to enter negotiations with that timeframe in mind.

COMMERCIAL CARGO/RESUPPLY

Question. What are NASA's plans with regard to future commercial cargo deliveries to the ISS, after 2015? Will the current contracts be extended or will there be a new competition?

Answer. NASA can continue to award some additional flights under the current CRS contracts. Beyond that, future competitions for cargo servicing will be awarded using competitive FAR-based contracts. See the answer to Question #13.

Question. For the Commercial Resupply Services program, will both of the cargo providers meet their obligations to supply the ISS by the dates originally agreed to by NASA? If not, why not, and will NASA have to renegotiate existing contracts in order to accomplish the programs purpose?

Answer. The CRS contract is a firm-fixed price, Indefinite Delivery Indefinite Quantity procurement with a period of performance from January 1, 2009, through December 30, 2016. The CRS contractors are not anticipated to complete on their original contract schedule, due in large part to the technical challenges of bringing new spacecraft and launch vehicles to operational status. However, NASA may elect to modify the current contracts to enable the completion of the flights. It is important to recall that the Agency only pays the contractors for milestones achieved.

ASTEROID

Question. The asteroid retrieval strategy outlined in the budget request proposes to augment existing activities in order to facilitate a potential mission in the future. Provide the changes in budget profile and timing if this augmentation is not provided.

Answer. NASA is pursuing ways to align key activities in Science, Space Technology, and Human Exploration and Operations Mission Directorates to improve detection and characterization of near-Earth asteroids (NEAs); including asteroids that could be potentially hazardous to the Earth; demonstrate advanced solar electric propulsion; and capture and redirect a small NEA to a stable orbit in the lunar vicinity. We would then use the Orion and Space Launch System assets to launch astronauts to the asteroid, perform rendezvous operations and return samples from it.

Changes in the budget have been requested for FY 2014 to accelerate the development of key technologies and capabilities for NASA, as well as enable the asteroid redirect mission. These capabilities are important in their own right independent of the proposed asteroid strategy. For example, STMD had planned to perform a high-powered Solar Electric Propulsion demonstration to support the needs of future human exploration as well as the commercial satellite sector. The FY

2014 budget request will allow NASA to accelerate the development and demonstration of these capabilities and define a mission concept to leverage existing efforts. The asteroid mission strategy, including the crewed segment using SLS and Orion, would provide a compelling near term mission and destination for exploration system capabilities. The asteroid mission fits well with the current development timelines for SLS and Orion and it would not require substantial added deep space architecture components implying an affordable near term destination. If the augmentation is not provided, a significant delay will occur in the advancement and demonstration of these critical technologies and capabilities. Further development of this compelling mission concept will be impaired or halted, depending on the magnitude of the cut to the request. In addition, momentum gained in human spaceflight for enhancing the objectives of initial missions of Orion and SLS toward this integrated opportunity will be at risk.

Question. Please explain the timing and chain of events that changed NASA's planning from sending astronauts to visit an asteroid to the currently proposed capture of an asteroid and bringing it back for examination?

Answer. As NASA planners worked different scenarios for the Agency's next human missions of exploration beyond low Earth orbit, they found that the potential mission to capture and redirect an asteroid into a stable lunar orbit for *in situ* study by astronauts had a number of advantages. First, it is a comparatively near-term goal (NASA is considering flying such a mission by the 2025 timeframe), which would enable the Agency to test out its initial deep-space architecture elements – the Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV) – without the need for the immediate development of other components needed for other destinations. Second, this proposal draws on work already underway in the Agency, including asteroid detection and tracking efforts, advanced solar-electric propulsion (SEP) development, and the development and initial flights of the SLS and Orion vehicles.

NASA has also spent significant time examining the potential for sending astronauts directly to a near earth asteroid. Such a mission includes several additional challenges. First, identifying a target NEA that is worthy of a visit in terms of science and exploration value, while keeping trip times and propellant requirements reasonable is challenging. Most identified NEA targets of significant value will require greater than 6 month round trip times. Such a mission will also require the development of additional exploration assets/capabilities such as a deep space habitat, space exploration vehicle (something with an airlock, manipulator arms as well as power and propulsion), long duration cryogenic storage, more reliable life support systems and a strategy for radiation protection. These capability requirements imply that the cost and schedule for a direct asteroid exploration mission is more challenging than the asteroid redirect mission. The Asteroid Redirect Mission would affordably support and leverage multiple efforts across the Agency as it paves the way for journeys to other destinations by helping NASA prove out its new heavy-lift launch vehicle and exploration spacecraft in a near-term mission.

Question. What is the technology readiness level of the propulsion and capture mechanisms intended to be used for a future asteroid retrieval mission and does NASA anticipate some technology demonstrations prior to the mission to reduce risk?

Answer. The Asteroid Redirect Mission will serve as a technology demonstration mission to validate the utility of high-powered solar electric propulsion and robotic capture mechanisms. Since this is a technology demonstration effort, the goal of this mission will be to mature these technologies for infusion into future NASA science and exploration missions.

The technology development to support a high-powered solar electric propulsion demonstration has been underway for the last two years through Space Technology's Game Changing Development program. The main technology components under development include:

- Solar Array Systems: These deployable high-power arrays feature twice the power for the same mass and three times the packaging efficiency relative to current array technologies. STMD selected two solar array system contractors (ATK and Deployable Space Systems) to develop advanced deployable arrays systems that can support the 30 kW to 50 kW required for the Asteroid Redirect Mission and that can scale to over 300 kW for future human exploration missions. This technology will reach TRL 5 by the middle of FY 2014. Space Technology will then be prepared to down-select one of the two vendors for inclusion into the SEP system for the flight demonstration.
- Electric Propulsion Thrusters: These magnetically shielded, high thrust Hall thrusters feature higher thrust levels (10 to 15 kW vs. 5 kW), higher specific impulse (3000 sec vs. 2000 sec) and magnetic shielding to significantly increase long duration operations. These thrusters will reach TRL 5 by mid FY 2014, with the potential for the procurement of engineering development units to support the asteroid redirect mission before the end of FY 2014. Alternate electric propulsion thruster solutions (besides magnetically shield Hall thrusters) are possible for the Asteroid Redirect Mission but will need to prove competitive in terms of mass, efficiency, specific impulse and technical maturity.
- Power processing units (PPUs) and power management and distribution (PMAD) systems: Multiple options for PPUs and the PMAD approach have been under development that can support the Asteroid Redirect Mission. These technologies will reach TRL 6 by the end of FY 2014.

Currently, with all technology components expected to complete development and testing during FY 2014, the Solar Electric Propulsion (SEP) system will be ready for the procurement of hardware supporting the flight demonstration by FY 2015. Currently, STMD is considering whether any precursor demonstration, to test the highest risk items, is warranted prior to the asteroid mission. In addition to the current baseline Hall-thruster SEP concept, STMD will study and consider other high-powered SEP concepts such as gridded ion and magneto-plasma systems to power the robotic spacecraft.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"Threats from Space: A Review of U.S. Government Efforts to Track and Mitigate Asteroids and Meteors, Part 1"

Questions for the Record, General Charles F. Bolden, Jr., Administrator
National Aeronautics and Space Administration (NASA)

Questions submitted by Rep. Steven Palazzo, Chairman, Subcommittee on Space

1. Many of our space assets are also extremely vulnerable to NEOs. Given our reliance on these assets, what plans are in place to mitigate potential damage to our satellites and the International Space Station?

    a. Do our current capabilities provide adequate tracking and warning of potential harmful impact to our space assets?
    b. What protocol has been established for giving advanced warning to U.S. government assets and are these also provided to the international community or commercial operators?
    c. How often do you have to alter the path of the ISS to avoid a possible debris strike? Is a lot of propellant used in doing so?

    ANSWER: It is highly unlikely that the International Space Station (ISS) or other assets in space would be struck by a sizeable NEO; however, space-based assets are hit by micrometeoroids and very small space debris frequently. The Joint Space Operations Center (JSpOC) and the NASA Trajectory Operations Center (TOPO) teams continuously monitor for potential collisions with debris of any significant size, and provide adequate notification so that avoidance maneuvers can be planned and executed.

    A total of 15 Debris Avoidance Maneuvers (DAMs) have been performed by ISS and the Space Shuttle from 1998 to present. Of those, the ISS has performed 11 and the Space Shuttle performed 4 while attached to ISS. A typical DAM would use about 75 kilograms of propellant.

2. Does NASA have the ability to track objects that could potentially be harmful to astronauts engaged in deep space exploration?

    ANSWER: The risk of impact from a NEO of the type being tracked by NASA to a deep-space mission is considered minimal. Though the risk is also very limited, spacecraft on deep-space missions would more likely encounter micrometeoroids, and these would not be tracked.

3. Please provide details of the recently signed Memorandum of Agreement between Air Force Space Command and NASA's Science Mission Directorate from January 18, 2013.

ANSWER: The recently signed MOA will support the NASA NEO program's ability to share information with the scientific community about fireball and bolide reports. Fireballs and bolides are astronomical terms for exceptionally bright meteors that are spectacular enough to be seen over a very wide area. The NEO program provides a chronological data summary of the brightest fireball and bolide events provided by U.S. Government sensors; this data summary can be accessed at http://neo.jpl.nasa.gov/fireballs/.

4. How often do we observe large meteors entering the atmosphere safely over the ocean?

ANSWER: Every day, a continual influx of meteors strikes Earth's atmosphere. Most of them are dust-sized particles, but it has been estimated that on a typical day, these particles total from 50 to 150 tons of matter. Asteroids of the order of a few meters in size strike the atmosphere roughly annually. About 70 percent of the Earth's surface is covered by water and asteroids do not originate from any preferred direction in the sky, so we expect that the majority of these annual impacts by meter-sized asteroids take place over the oceans. Larger asteroid impacts are even less frequent; an asteroid as large as 140 meters in diameter striking the Earth is estimated to average about 1 in 30,000 years.

5. What capabilities does the U.S. government already possess to detect and track asteroids? What level of fidelity is needed compared to the level of fidelity we currently have?

ANSWER: NASA sponsors a number of activities relating to the search for NEOs under its Near Earth Object Observation (NEOO) program, including: work at the international Minor Planet Center (MPC), located at the Harvard-Smithsonian Center for Astrophysics, which collects and correlates NEO orbit data provided by observatories around the world; surveys conducted by several search teams operating ground-based optical telescopes; activities at the NASA NEO Program Office at the Jet Propulsion Laboratory (JPL), which coordinates assessments of NEO orbits and computes impact probabilities; and, research at two radio-telescope facilities that provide precision tracking and characterization of NEOs. There are also cooperative projects involving NASA, the National Science Foundation (NSF), which has a key role within the United States for ground-based astronomical assets, and the U.S. Air Force (USAF) Panoramic Survey Telescope and Rapid Response System (PanSTARRS) program, as well as non-government academic and space research organizations. Additionally, NEO detection is a major science driver for the proposed Large Synoptic Survey Telescope. NASA is also working with the Canadian Space Agency (CSA) on processing of data that will be collected from their recently launched Near-Earth Object Surveillance Satellite (NEOSSat).

These assets constitute an effective program for discovering larger NEOs, and we are working to improve our capabilities for the identification and characterization of smaller, few hundred meter sized NEOs. Small NEOs are difficult to detect in visible light from ground-based telescopes because the small, dark objects reflect only a small amount of visible sunlight. In contrast, telescopes sensitive to infrared light detect an object's radiated heat, rather than reflected sunlight; even small, dark asteroids could be detected by a telescope sensitive to infrared light, making these capabilities particularly relevant for future NEO surveys. However, these sensors must operate outside the Earth's atmosphere to be effective.

6. Please provide a status update on the activities of NASA's Near Earth Objects Office.

   __ANSWER:__ The purpose of NASA's Near Earth Object Observations (NEOO) Program is to coordinate NASA-sponsored efforts to detect, track, and characterize potentially hazardous asteroids and comets that could approach the Earth. As noted in the response to Question 5, the NEOO Program continues to support a number of activities relating to the search for NEOs with our partners. In particular, the Minor Planet Center in Cambridge, Massachusetts, has 100M observations of NEOs in its database and 27,000 observations are added daily. Today, the NEOO Program has catalogued more than 95 percent of all NEOs over one-kilometer in size and about 25 percent of the 140-meter or larger sized NEO population has been discovered. The current discovery rate of NEOs is approximately 1,000 per year, up 50 percent since 2007. None of the NEOs found to date has a significant chance of hitting Earth in the next century. Thus the near-term risk of an unwarned impact from a large asteroid, and hence the majority of the risk from all NEOs, has been reduced by more than 90 percent.

7. In 1998, NASA commenced an effort with the goal of discovering and tracking over 90 percent of the near-Earth objects larger than one kilometer by the end of 2008. How successful was that effort, what can we learn from it today?

   __ANSWER:__ By the end of 2010, the NEOO Program had reached the goal of cataloguing more than 90 percent of all NEOs over one-kilometer in size at a cost of less than $50M. NASA worked with a number of ground-based observatories and partners as part of our Spaceguard survey to reach that goal; and NASA has now catalogued more than 95 percent of all NEOs over one-kilometer in size.

   Through this process, we have learned that partnerships such as these are essential to meeting the future goals of detecting smaller objects. As such, NASA's NEOO Program has initiated development of several additional capabilities to the NEO detection network, with the recent additional funding it received starting in FY 2012. Some of these involve collaboration on projects with the Defense Advanced Research Projects Agency (DARPA) and the U.S. Air Force, such as background detection of asteroids by the new Space Surveillance Telescope (SST), which is on track to start routinely providing observations in 2013. There is also the planned augmentation of the USAF Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) facility with a second aperture. The wide field of view survey capabilities of these two assets are expected to provide a significant increase in NEO detection rate.

8. When asteroid expeditions are at the center of human spaceflight plans for NASA, and when commercial companies are taking an interest in finding and then profiting from asteroids, and when our ability to avoid a cosmic catastrophe depends absolutely on the knowledge of the orbits of hundreds of thousands (if not millions) of asteroids, why has NASA not funded the effective space-based search telescope needed for all these missions? With Chelyabinsk, will it now receive priority? If not funded, are we to conclude that NASA is not serious about pursuing any of these space endeavors?

<u>**ANSWER:**</u> NASA leads the world in the detection and characterization of NEOs, and provides critical funding to support the ground-based observatories that are responsible for the discovery of about 98 percent of all known NEOs. However, ground-based telescopes will always be limited to the night sky and by weather. The only way to overcome these impediments is to use the vantage point of space. The privately funded B612 Foundation is planning to build a space observatory called Sentinel that would launch in 2018 and detect 100-meter sized objects and larger that could come near Earth's orbit. Sentinel will employ an infrared telescope from a Venus-orbit that will look out directly opposite the Sun at the space surrounding Earth's orbit in order to see and track near Earth objects. NASA is working collaboratively with the B612 Foundation by providing technical assistance and operational support through a Space Act Agreement. A NASA Technical Consulting Team was established to support the B612 project reviews. NASA will also provide B612 access to our Deep Space Network for telecommunications with the Sentinel spacecraft for commanding and data downlink. NASA is also evaluating reactivating our NEOWISE activity, a very successful use of an Earth-orbiting, Wide-field Infrared Survey Explorer (WISE) space telescope that was used in 2010-2011 to find and physically characterize near-Earth objects.

To find the more numerous smaller asteroids near Earth, NASA's Human Exploration and Operations Mission Directorate (HEOMD) and Science Mission Directorate (SMD), through the Joint Robotic Precursor Activity (JRPA) office, are studying instrument concepts for a mission of opportunity to be hosted on a U.S. government or commercial spacecraft in geosynchronous orbit that would be capable of detecting and tracking asteroids in orbits very similar to Earth's. This modest-sized, wide field telescope would have detectors that operate in the infrared bands where these faint asteroids are more easily detected against the cold background of space. NASA released a Request for Information (RFI) in August 2012 and is studying the instrument concepts that were submitted. Work is also underway to draft an Announcement of Opportunity (AO) to request proposals for Phase A studies. It is likely that NASA could fund up to three instrument concepts for Phase A studies, culminating with a down select to one proposal in FY 2014.

Questions for the Record
Ranking Member Eddie Bernice Johnson
"Threats from Space: A Review of U.S. Government Efforts to Track and Mitigate Asteroids and Meteors, Part I"
March 19, 2013

1. Will sequestration cause a delay to meeting the Congressionally-mandated goal of detecting 90 percent of NEOs 140 meters in diameter and larger by 2020? If so, by how long?

   ANSWER: The purpose of NASA's Near Earth Object Observations (NEOO) Program is to coordinate NASA-sponsored efforts to detect, track, and characterize potentially hazardous asteroids and comets that could approach the Earth. Currently, sequestration will not have an effect on NEOO Program funding; however, long-term sequestration (past the current fiscal year) could potentially impact programs and projects across the Agency and will be assessed by the Science Mission Directorate as needed.

2. What would be required for NASA to detect 90 percent of NEOs 15 meters in diameter and larger by 2020? What approach(es) would NASA recommend be taken to achieve that goal?

   ANSWER: To find 90 percent of 15 meter NEOs by 2020 would require a program of multiple space-based telescopes to accomplish when it may be several decades before Earth again is hit by something larger than 15 meters. Such a program is currently not achievable with the existing budget profile. The approach within the NEOO Program in the President's FY 2014 budget request is to expand the existing NEO detection and characterization activities to detect the NEO population at a measured pace. Making available more time on existing ground-based observatories, such as the USAF Pan-STARRS, the NASA Infra-Red Telescope Facility (IRTF), or the Space Surveillance Telescope (SST), would be the first step.

   While ground-based surveys are making excellent progress increasing the discovery rate, it would require a space-based infrared NEO telescope to significantly increase the current detection rate. Such a telescope would capture the asteroid's solar energy re-radiated in the infrared and do so without interruptions from daylight and weather. Not only would such a telescope efficiently discover NEOs, it could (unlike ground-based optical discovery telescopes) also estimate their diameters to a confidence level of about 20 percent. The B612 Foundation has announced plans to philanthropically fund an effort to operate an infrared telescope in a Venus-like orbit. NASA has signed a Space Act Agreement with B612 to provide advisory information as well as spacecraft tracking and navigation support. NASA has also funded an advanced infrared detector development that could be employed on an infrared telescope operating at the Sun-Earth L1 position.

In addition, NASA is advancing work on instrument concepts for a mission of opportunity to be hosted on a U.S. government or commercial spacecraft in geosynchronous orbit that would be capable of detecting and tracking asteroids in orbits very similar to Earth's. NASA is also evaluating reactivating our NEOWISE activity, a very successful use of an Earth-orbiting, Wide-field Infrared Survey Explorer (WISE) space telescope that was used in 2010-2011 to find and physically characterize near-Earth objects.

Questions for the Record
Representative Donna F. Edwards
"Threats from Space: A Review of U.S. Government Efforts to Track and Mitigate Asteroids and Meteors, Part 1"
March 19, 2013

1. It is clear that threats from objects 30-50 meters in diameter or smaller, such as the one that unexpectedly entered the atmosphere and exploded over Russia can cause harm.
    - Is NASA's current NEO survey program capable of identifying threats from objects of this size?
    - If not, how important is it to start identifying this class of small threatening objects if we are to come up with an effective protection strategy?
    - How difficult a task would it be?

    <u>ANSWER:</u> Since 1998, NASA has supported several ground-based optical telescope facilities for discovering and following-up NEOs. The progress for finding NEOs larger than one kilometer has been very impressive with a total discovery completion rate of more than 95 percent. However, there are vastly more small NEOs with much larger impact probabilities than large ones. NASA's NEOO Program is capable of identifying these objects; however, the current discovery completion for 30-40 meter sized objects is now less than one percent. While NEOs in this size range can cause local property damage and injuries, our current focus is on completing the Congressionally-mandated survey of NEOs larger than 140 meters, which can cause much more serious damage.

    Small NEOs are difficult to detect in visible light from our current ground-based telescopes because the small; dark objects reflect only a small amount of visible sunlight. In contrast, telescopes sensitive to infrared light detect an object's radiated heat, rather than reflected sunlight; even small, dark asteroids could be detected by a telescope sensitive to infrared light, making these capabilities particularly relevant for future NEO surveys. However, these sensors must operate outside the Earth's atmosphere to be effective.

2. As you know, the Ad-Hoc Task Force on Planetary Defense of the NASA Advisory Council was set up to advise the Council Chairman, you, and NASA Mission Directorates on future agency actions related to Planetary Defense. The Task Force made five recommendations in October 2010 on how NASA should organize, acquire, investigate, prepare for, and lead national and international efforts in Planetary Defense. How were these recommendations subsequently addressed by NASA? What has happened to this Ad-Hoc Task Force since 2010?

    <u>ANSWER:</u> The five recommendations made by the Task Force were to: Organize for Effective Action on Planetary Defense; Acquire Essential Search, Tracking, and Warning Capabilities; Investigate the Nature of the Impact Threat; Prepare the Response to Impact Threats; and Lead U.S. Planetary Defense Efforts in National and International Forums. NASA has acted on these recommendations in several ways.

The purpose of NASA's Near Earth Object Observations (NEOO) Program is to coordinate NASA-sponsored efforts to detect, track, and characterize potentially hazardous asteroids and comets that could approach the Earth. In FY 2010, the NASA budget for the NEOO Program was $5.8M. The final report of the NASA Advisory Council Ad-Hoc Task Force on Planetary Defense was provided to the NASA Administrator in October 2010. NASA's budget formulation process for the subsequent President's budget request resulted in an Administration request of $20M for the NEOO Program in FY 2011 and $20.4M for FY 2012. The FY 2014 budget request for NASA includes $40.5M for the NEOO Program for near-Earth asteroid detection, follow-up and characterization.

Within the increased investment in the NEOO Program, the FY 2014 budget request includes focused support for partnerships and leveraging, including international and commercial partnerships. The objectives of the enhanced NEOO Program are responsive to the Task Force's recommendations to Acquire Essential Search, Tracking, and Warning Capabilities; and Investigate the Nature of the Impact Threat.

In addition, NASA has taken specific action to strengthen the leadership of U.S. planetary defense efforts in national and international forums. The NASA NEOO Program has provided essential leadership to the United Nations Committee on Peaceful Uses of Outer Space action team on the NEO threat. That group is developing a plan for an enhanced international asteroid warning network, impact disaster planning, space-mitigation mission planning should there be a credible threat, and advice on planning and response.

To "Prepare the Response to Impact Threats" on April 3, 2013, the NEOO Program and the Department of Homeland Security's Federal Emergency Management Agency (FEMA) held a one-day simulation of impact disaster response with NEO observation, detection and mitigation community experts and FEMA emergency-response personnel. Also, the Planetary Defense Conference, hosted in April 2013 in Flagstaff, AZ, conducted a half-day international impact-emergency-response exercise with participants from multiple countries.

3. In your prepared statement you noted that "NASA also is investigating development of an instrument that could be hosted on geo-synchronous platforms such as communications, TV broadcast or weather satellites" to detect the more numerous smaller asteroids near Earth. When do you anticipate this instrument being available? How much will it cost and what is your level of confidence that other entities will host the instrument on their platforms?
   - What are the expected outcomes from such a program and what are the criteria for determining whether or not to continue using this approach for NEO detection?

ANSWER: To find the more numerous smaller asteroids near Earth, NASA's Human Exploration and Operations Mission Directorate (HEOMD) and Science Mission Directorate (SMD), through the Joint Robotic Precursor Activity (JRPA) office, are studying instrument concepts for a mission of opportunity to be hosted on a U.S. government or commercial spacecraft in geosynchronous orbit that would be capable of detecting and tracking asteroids in orbits very similar to Earth's. This modest-sized, wide field telescope would have detectors that operate in the infrared bands where these faint asteroids are more easily detected against the cold background of space. NASA released a Request for Information (RFI) in August 2012, and is studying the instrument concepts that were submitted. Work is also underway to draft an Announcement of Opportunity (AO) to request proposals for Phase A studies. It is likely that NASA could fund up to three instrument concepts for Phase A studies, culminating with a down select to one proposal in FY 2014. This effort has the goal of being ready to deploy the first hosted instrument by the end of 2016 for a cost of less than $50M.

4. A NEO object, Apophis, estimated at 325 meters in diameter, has been the focus of much attention and monitoring since it was discovered in 2004. It is projected to have a significant threat of potential impact at some point in the future. What is NASA's current assessment of Apophis' threat and what is needed to improve our understanding of the threat?

   ANSWER: Any significant probability of Apophis impacting the Earth in 2029 was eliminated within a few weeks of its discovery using archived images that allowed a significant extension of the observed orbital track. A small possibility (1 in a few thousand) of impact remained in 2036 until radar observations collected in early 2013 eliminated that event as well. There remains an incrementally small chance of impact in 2068, but it is now assessed at less than 3 in a million.

5. How important is the Arecibo Observatory to NASA's NEO activities?

   ANSWER: The Arecibo Observatory is home to the world's largest and most sensitive single-dish radio telescope, and is one of two radar facilities we use for tracking and improving our knowledge of NEOs. As NEOs are discovered and come into its effective range, the Arecibo Observatory conducts follow-up radar observations to measure specifics such as the distances, sizes and spin rates of the objects, which improve our knowledge of their orbits and help calculate the risks of potential impacts. The rotation rate, shape and reflectivity gathered from the Arecibo images can also give us information about the asteroids' density and surface properties.

QUESTIONS FOR THE RECORD
THE HONORABLE RANDY NEUGEBAUER (R-TX)
U.S. House Committee on Science, Space, and Technology

Threats from Space:
A Review of U.S. Government Efforts to Track and Mitigate Asteroids and Meteors, Part I

1. What does NASA consider an adequate annual funding level for planetary defense activities?

   ANSWER: NASA sponsors a number of activities relating to the search for NEOs and planetary defense related activities under its Near Earth Object Observation (NEOO) program, including work at the international Minor Planet Center (MPC), located at the Harvard-Smithsonian Center for Astrophysics, which collects and correlates NEO orbit data; research at two radio-telescope facilities that help provide precision tracking and characterization of NEOs; surveys conducted by ground-based optical telescopes; and activities at the NASA NEO Program Office at the Jet Propulsion Laboratory (JPL), which coordinates assessments of NEO orbits and impact probabilities. The NEOO program funding was $20.4M in FY 2012. The FY 2014 President's budget request increases this funding to $40.5M, to enhance existing assets that detect and characterize NEOs and initiate development of an instrument that could be hosted on geo-synchronous platforms to detect the more numerous smaller asteroids near Earth.

2. What is the likelihood of such a devastating impact from a near earth asteroid? Are the resources necessary for a credible program worth the cost given the low probability of such an occurrence in our lifetimes?

   ANSWER: Although impact of a large asteroid is an exceeding rare event, one of the key conclusions of the 2003 NASA report entitled "Study to Determine the Feasibility of Extending the Search for Near-Earth Objects to Smaller Limiting Diameters" was that "the benefits derived from all (NEO) search systems match or exceed their costs within the first year of operation." Especially for the larger NEOs, current search efforts are well worth their modest costs, since an early discovery of an Earth threatening NEO would allow the time to safely deflect it with existing technologies. As the search for NEOs continues, and more and more of them are discovered and tracked one hundred or more years into the future, their risks to Earth can be evaluated. More than 95 percent of the largest NEOs (1 kilometer and larger) have already been discovered for a total cost of less than $70M spread over 15 years, and it is reassuring to know that none represent a serious impact threat in the next one hundred years. Despite the low probability of a devastating NEO impact, it seems prudent to continue to invest in strategies for early warning and mitigation.

Question for the Record
Representative Ami Bera

Threats from Space: A Review of U.S. Government Efforts to Track and Mitigate Asteroids and Meteors, Part 1"

March 19, 2013

1. Astronomy is one of our oldest natural sciences, studied and researched by ancient civilizations before the invention of the telescope, and other modern technologies and sciences. Dating back to 2500 B.C., early records reveal that people kept detailed astronomical accounts of objects they discovered and that practice continues today.

   In the United States, tens of thousands of amateur astronomers create home observatories or assemble at professional observatories and collaborate on finding new celestial objects, ranging from stars, planets, asteroids, etc. These amateur astronomers are found across the globe, even in my home county of Sacran1ento, CA as a part of the Astronomy Connection of Sacramento (TAC-SAC) and are making incredible discoveries every day.

   My question is for you General Bolden. What steps can Congress and NASA take to further create and facilitate this open source of information sharing to increase our eyes in the sky for detecting near-Earth objects? How can NASA leverage the passion of amateur astronomy and engage the thousands that practice it to help increase our knowledge and awareness of the asteroids and meteors that are located near Earth?

   ANSWER: Since 1998, NASA has supported several ground-based optical telescope facilities and received observations from numerous amateur astronomers for discovering and following-up NEOs. The international community of NEO researchers is well coordinated and has been working cooperatively for several years. In addition, the international communication and data sharing channels are operating successfully.

   Once a NEO discovery is made, a combination of professional and amateur astronomers provide the critically important follow-up optical observations that allow accurate orbits to be computed and the NEO's motion to then be accurately predicted for more than one hundred years into the future. Radar observations, if available, are especially good for orbit refinement and for determining the NEO's size, shape and rotation characteristics. In addition, many amateur astronomers provide an observed time history of the NEO's ability to reflect light and hence, if these objects are irregularly shaped, these types of observations can be used to determine the rotation rate of the NEO. Given the success of this coordinated effort, NASA will continue to leverage the knowledge and awareness of the NEO community in its entirety.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
"An Overview of the National Aeronautics and Space Administration
Budget for Fiscal Year 2014"
Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Rep. Steven Palazzo, Chairman, Subcommittee on Space

QUESTION 1:

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

ANSWER 1:

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

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

QUESTION 2:

A report issued last December by the National Academy of Sciences about NASA's strategic direction stated, "[t]he committee has seen little evidence that a current stated goal for NASA's human spaceflight program-namely, to visit an asteroid by 2025-has been widely accepted as a compelling destination by NASA's own workforce, by the nation as a whole, or by the international community. On the international front there appears to be continued enthusiasm for a mission to the Moon but not for an asteroid mission." Why is this mission any different?

ANSWER 2:

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

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

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

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

QUESTION 3:

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

ANSWER 3:

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

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

QUESTION 4:

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

ANSWER 4:

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

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

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

QUESTION 5:

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

ANSWER 5:

While the OSIRIS-REx and Hayabusa missions were driven by science objectives, ARM planning brings together the best of NASA's science, technology and human exploration efforts to achieve this great technological feat. Crewed rendezvous with and exploration of the redirected asteroid will occur in the lunar vicinity. This mission prepares us for future long duration deep space missions, but also exploits the near term learning opportunities in near lunar space. Astrodynamically stable regions in the lunar vicinity offer locales for early operations in the deep space environment. Lunar distant retrograde orbits offer an ideal venue for initial crewed operations in regions in which returns to Earth are impossible for many days. Interactions with an asteroid in this region will allow NASA to test and gain operational experience in proximity operations and rendezvous with a non-cooperative target, astronaut experience in complex extra vehicular activity (EVA), and sample collection, handling and return. This also provides NASA valuable experience practicing aborts and contingency procedures needed for operations outside the Earth's gravity well, and handling maintenance and repair, including with EVAs. This mission is a step in a Flexible Path approach, a steadily advancing, measured, and publicly notable human exploration of space beyond Earth orbit that would build our capability to explore, enable scientific and economic return, and engage the public[1]. NASA will take steps toward Mars, learning to live and work in free-space and near planets; under the conditions humans will meet on the way toward Mars[1]. Augustine et al recommended in a strategy summary, that "...Before we explore Mars, we will likely do some of both the Flexible Path and lunar exploration — the primary decision *is one of sequence*. This will be largely guided by budgetary, programmatic, and program sustainability considerations[1]."

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

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

QUESTION 6:

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

ANSWER 6:

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

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

QUESTION 7:

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

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

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

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

ANSWER 7:

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

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

QUESTION 8:

You have repeatedly said that without the requested amount for the Commercial Crew program, the timeline for crewed flights would slip and routine flights to station will not start in 2017 as planned. How many providers are you assuming when making that statement? Could we maintain the 2017 milestone within that $500M ceiling by carrying fewer partners or an alternative development strategy?

ANSWER 8:

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

QUESTION 9:

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

ANSWER 9:

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

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

QUESTION 10:

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

ANSWER 10:

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

QUESTION 11:

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

ANSWER 11:

NASA is working to encourage the growth of a low Earth orbit (LEO) space economy that will continue to develop even after the end of International Space Station's (ISS) lifetime. Private enterprise and affordable commercial operations in LEO will enable a truly sustainable step in our expansion into space — a robust, vibrant, commercial enterprise with many providers and a wide range of private and public users will enable U.S. industry to support NASA and other Government and commercial users safely, reliably, and at a lower cost.

QUESTION 12:

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

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

ANSWER 12:

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

Specifically the two deliverables/gates are defined as:

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

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

QUESTION 13:

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

ANSWER 13:

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

QUESTION 14:

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

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

ANSWER 14a:

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

QUESTION 14b:

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

ANSWER 14b:

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

QUESTION 14c:

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

ANSWER 14c:

NASA anticipates that commercial crew transportation services to ISS will be available in 2017. If this is not the case, and if Russian Soyuz services are also unavailable, NASA could potentially move the 2021 date of the crewed test flight forward with increased funding, fulfilling the back-up role of SLS/Orion; however, this would be a highly inefficient use of the Orion and the SLS.

QUESTION 14d:

How much would it cost for this capability?

ANSWER 14d:

A rough estimate of the costs for this capability by FY 2021 are about $1.3B above the baseline estimate for a single mission to the ISS. The estimate includes the shifting of the first crewed flight test forward, Exploration Mission-2 to 2018, and the development of a mission kit that provides ISS contingency docking capability in the event other vehicles are unable to perform the mission. No cost commitment is currently in place.

QUESTION 15:

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

ANSWER 15:

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

QUESTION 16:

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

ANSWER 16:

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

QUESTION 17:

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

ANSWER 17:

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

QUESTION 18:

Is Orion dependent on European development of a service module?

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

ANSWER 18a:

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

QUESTION 18b:

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

ANSWER 18b:

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

QUESTION 19:

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

ANSWER 19:

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

QUESTION 20:

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

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

ANSWER 20a:

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

QUESTION 20b:

Is an upper stage needed for the proposed asteroid mission?

ANSWER 20b:

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

QUESTION 20c:

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

ANSWER 20c:

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

QUESTION 21:

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

ANSWER 21:

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

QUESTION 22:

Has NASA conducted a review of research goals that would inform the needed operational lifetime of the ISS?

ANSWER 22:

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

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

QUESTION 23:

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

ANSWER 23:

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

QUESTION 24:

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

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

ANSWER 24a:

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

QUESTION 24b:

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

ANSWER 24b:

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

QUESTION 24c:

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

ANSWER 24c:

The President's FY 2014 budget request appropriately provides NASA with the funds as well as the responsibilities for designing and implementing an architecture for sustained provision of the solar irradiance, ozone profile, and Earth radiation budget information important for NASA – and indeed national - science programs. Within the NASA Science Mission Directorate (SMD), the Joint Agency Satellite Division takes responsibility only for those activities, which are implemented by NASA but are funded by other agencies. The Earth Science Division (ESD) has the responsibility for design, implementation, and exploitation of Earth-related missions that are funded by NASA. By conducting the architecture design and implementation of these measurements in ESD, the Nation will benefit from the largest potential solution set for achieving these measurements, and the maximum synergy by making use of the entire ESD portfolio of missions and techniques. The Administration has made the decision to pursue the work through ESD.

QUESTION 25:

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

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

ANSWER 25a:

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

QUESTION 25b:

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

ANSWER 25b:

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

QUESTION 26:

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

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

ANSWER 26a:

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

QUESTION 26b:

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

ANSWER 26b:

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

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

QUESTION 26c:

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

ANSWER 26c:

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

QUESTION 26d:

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

ANSWER 26d:

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

QUESTION 27:

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

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

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

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

ANSWER 27:

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

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

QUESTION 28:

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

ANSWER 28:

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

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

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

QUESTION 29:

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

ANSWER 29:

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

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

QUESTION 30:

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

ANSWER 30:

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

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

QUESTION 31:

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

ANSWER 31:

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

QUESTION 32:

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

ANSWER 32:

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

Within the NASA Advanced Exploration Systems (AES) Division in the Human Exploration and Operations Mission Directorate (HEOMD), NASA civil servants at the Johnson Space Center (JSC) are developing an in-house prototype EVA suit and EVA life support system. This in-house development activity is utilizing NASA developed technology along with contractor provided components from many providers. The objective of the in-house development activity is to gain operational and performance data on the new technology elements in ground simulation and testing environments.

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

QUESTION 33:

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

ANSWER 33:

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

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

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

QUESTION 34:

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

ANSWER 34:

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

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

		Foot Wind Tunnel at NASA Ames Research Center.				

QUESTION 35:

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

ANSWER 35:

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

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

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

QUESTION 36:

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

ANSWER 36:

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

QUESTION 37:

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

ANSWER 37:

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

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

QUESTION 38:

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

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

ANSWER 38:

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

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

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

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

QUESTION 39:

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

ANSWER 39:

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

QUESTION 40:

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

ANSWER 40:

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

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

QUESTION 41:

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

ANSWER 41:

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

QUESTION 42:

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

ANSWER 42:

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

QUESTION 43:

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

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

ANSWER 43:

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

In FY 2014, DOE is transitioning to a full cost recovery strategy for RPS. NASA is the primary user of the relevant facilities, so the Administration's approach is for NASA to provide the full funding so that RPS program requirements and funding are aligned under one agency. Requested FY 2014 funding and justification for the sustainment of all necessary supporting infrastructure and capabilities are included in the NASA budget request. The required funding for DOE RPS infrastructure covers maintaining unique program, facility and safety infrastructure in a safe, operable state to include: trained operators, accountability of nuclear material inventories, reliably operable equipment, up-to-date facility safety documentation, maintenance, utilities, waste management, technical and administrative support, and modeling and analysis capabilities. User programs pay incremental costs for mission-specific hardware and analyses.

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

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

QUESTION 44:

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

ANSWER 44:

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

QUESTION 45:

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

ANSWER 45:

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

QUESTION 46:

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

ANSWER 46:

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

QUESTION 47:

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

ANSWER 47:

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

The charter for STMD makes it clear that the new Mission Directorate takes a balanced portfolio approach to its investment portfolio to include early stage conceptual studies of entirely new technologies; mid level technology development with ground-based testing and prototype validation; and relevant environment flight demonstrations to verify mission infusion readiness. Such a portfolio-based approach ensures that the most urgently needed near term technologies are demonstrated and infused into future NASA missions quickly, while maintaining a pipeline for the technologies that will be needed in the future.

QUESTION 47a:

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

ANSWER 47a:

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

QUESTION 47b:

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

ANSWER 47b:

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

In the Science arena, current STMD investments will demonstrate laser or optical communications to increase communications bandwidth of NASA's space communications assets allowing us to receive more data from spacecraft studying the far corners of our solar system. We are also developing space based atomic clock technologies to improve accuracy of navigation systems. Space Technology will demonstrate a Solar sail seven times larger than any solar sail tested in space to date; a technology with tremendous potential for future heliophysics missions. In each case, these demonstration missions will enable future science missions not possible today while providing a backbone for capabilities that are of significant benefit to future human exploration missions. For example, both the laser communications and atomic clocks demonstration missions involve cost sharing by the Human Exploration and Operations Mission Directorate (HEOMD), indicating the level of synergy and cooperation.

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

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

QUESTION 47c:

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

ANSWER 47c:

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

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

QUESTION 48:

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

ANSWER 48:

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

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

QUESTION 49:

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

ANSWER 49:

Less capable Solar Electric Propulsion (SEP) systems are available now and have been used for a variety of spacecraft over the last decade to manage station keeping and provide continuous thrust for deep space missions with the appropriate mission profile. For NASA, this included Deep Space 1 and Dawn, which is on course for reaching the Ceres asteroid in 2015. The current SEP system being developed for a demonstration class mission will provide between 30 and 50 kilowatts of power. The final objective system that HEOMD envisions for its deep space exploration missions involves a 300 kilowatt system. To permit the development of a 300 kilowatt system, many technology elements including: advanced high power solar arrays, advanced high power thrusters and a new generation of power management and power processing systems, will be needed relative to current SEP capabilities. The main purpose of the 30 kW demonstration class system is to develop, integrate and demonstrate these advanced component technologies such that clear extensibility to the 300 kW HEOMD systems is validated. In turns out that such a 30 kW demonstration system can also be directly applied to science as well as DoD missions not feasible today. Furthermore the component technologies, particularly the advanced solar arrays, will have direct commercial applicability to future communications satellites.

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

QUESTION 50:

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

ANSWER 50:

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

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

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

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

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

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

QUESTION 51:

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

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

ANSWER 51:

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

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

<u>eCustoms Visual Compliance Database Checks:</u>

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

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

QUESTION 52:

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

ANSWER 52:

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

QUESTION 53:

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

ANSWER 53:

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

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

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

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

QUESTION 54:

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

ANSWER 54:

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

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

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

The request is sponsored for verification of need. If an application is marked as containing export control data, then the Center export control reviews the request prior to the application approves access. The application approvers review the export control provisos/conditions for the foreign national user before granting access.

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

QUESTION 55:

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

ANSWER 55:

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

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

Within NASA, multiple offices are tasked with the responsibilities of securing NASA's resources. They are: (1) the Office of the Chief Information Officer (OCIO), with statutory responsibility for all unclassified information technology and unclassified information; (2) the Office of International and Interagency Relations (OIIR), with designated responsibility for Export Control; and, (3) the Office of Protective Services (OPS) which is responsible for all of NASA's physical, personnel and information security policies for classified systems and headquarters administration activities, protection program management and emergency management, intelligence reporting and analysis, special access programs, communications security (COMSEC), operation of all NASA's classified national security systems, and all counterintelligence and counterterrorism activities agency-wide.

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

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

QUESTION 56:

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

ANSWER 56:

NASA met the initial Personal Identification Verification (PIV) issuance requirement in October 2008. PIV enabled physical access has been in place since 2008. PIV enabled network access has been in place since 2010. PIV enabled application access is in progress. The NASA-wide PIV mandatory pilot began in FY 2013 and is progressing towards a production rollout before the end of FY 2013. All windows systems are expected to be complete by Q4 FY 2014. Enabling PIV card log in of non-windows systems will take longer, depending on availability of third party products, funding for the products, integration, testing, and deployment.

QUESTION 57:

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

ANSWER 57:

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

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

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

QUESTION 58:

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

ANSWER 58:

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

QUESTION 59:

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

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

ANSWER 59:

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

QUESTION 60:

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

ANSWER 60:

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

NASA is looking carefully at each of these technology and capability areas to identify development plans, which reflect maturation of the Technology Readiness Levels (TRLs). As funding and partnerships with commercial or international partners allow, missions will be assembled from these capabilities to further the exploration goals along the CDF. NASA is currently developing the Space Launch System (SLS) and Orion crew vehicle that will provide the initial capability for crewed exploration missions beyond low-Earth orbit (LEO) with an initial exploration mission flight test in 2017. In parallel, the other core systems capabilities will be developed, prioritized, and matured to ensure meaningful progress for human exploration beyond LEO. Beginning with exploration systems testing on the International Space Station, followed by the initial Orion/SLS flight tests and along with the Asteroid Redirect Mission (ARM), NASA will demonstrate evolution of critical technologies, techniques, and operations in the near-term that will be required for future Mars exploration systems and allow humans to safely travel across and explore the solar system.

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

QUESTION 1:

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

ANSWER 1:

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

QUESTION 1a:

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

ANSWER 1a:

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

QUESTION 1b:

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

ANSWER 1b:

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

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

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

QUESTION 1c:

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

ANSWER 1c:

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

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

QUESTION 2:

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

ANSWER 2:

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

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

Early beyond-Earth-orbit missions utilize human spaceflight capabilities currently under development in important ways in the early 2020s. Astrodynamically stable regions in the lunar vicinity offer locales for early operational experience in deep space. The crewed mission to a redirected asteroid would enhance current test objectives for early flights of SLS and Orion to provide important additional experience in human spaceflight beyond Earth orbit toward the ultimate goal of a crewed mission to Mars. The round-trip missions greater than 20 days to the asteroid will include highly limited resources and no ability to quickly return/abort to Earth coupled with operation of the Orion crew vehicle during missions to encounter and sample the asteroid. The complex trajectories in the trip to the asteroid in a distant retrograde orbit around the Moon; rendezvous and proximity operations using the Orion spacecraft in deep-space environments; deep-space operations such as guidance, navigation and control nine days away from Earth; EVAs in this deep-space environment to explore the asteroid, and extraction, management; and return of samples in the Orion will all be challenging and inspirational early operations in translunar space that retire significant risk in preparation for future Mars missions.

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

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

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

QUESTION 3:

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

ANSWER 3:

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

QUESTION 3a:

For how many more years could the ISS operate safely?

ANSWER 3a:

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

QUESTION 3b:

What specifically is the ISS supposed to accomplish by 2020?

ANSWER 3b:

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

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

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

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

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

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

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

QUESTION 3c:

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

ANSWER 3c:

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

QUESTION 3d:

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

ANSWER 3d:

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

QUESTION 3e:

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

ANSWER 3e:

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

QUESTION 4:

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

ANSWER 4:

Natural and human-induced changes in the Earth system – from our planet's interior to the land surface, atmosphere and oceans – affect all aspects of life. If we are to understand and respond to those changes, we need a foundation of observations collected from the land, sea, air and space, integrated with models and other tools to develop the necessary information to make decisions. The Nation has invested significantly in developing this capability to conduct Earth science research within NASA. The Agency's Earth Science program represents a 55 percent contribution to the USGCRP and offers a unique view from space and the long-term data record necessary to support the work of USGCRP. The NASA Earth Science program provides leadership to USGCRP by advancing our understanding of integrated Earth systems, including the global atmosphere, oceans and sea ice, land surfaces, ecosystems, and how these systems affect – and are affected by – humans. The NASA Earth Science program continues to lead the international science community in observing our home planet and understanding it through scientific research. The funding ensures that the United States can continue to lead the world in global-scale observations exploration of the integrated Earth system.

QUESTION 5:

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

ANSWER 5:

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

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

QUESTION 5a:

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

ANSWER 5a:

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

QUESTION 6:

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

ANSWER 6:

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

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

QUESTION 7:

The Aerospace Safety Advisory Panel (ASAP) stated in its FY 2012 Annual report that: "NASA's continued retention of the SAA [Space Act Agreement] flight demo option raises questions in our minds about the government's safety obligations as well as how such an option would move NASA any closer to a certified system. It could also lead NASA down the slippery slope of being forced to curtail their certification program for NASA crewmembers merely because of a small number of possibly lucky, non-certified flights. We do not understand the full implication of the optional approach and are concerned that it increases risk. "

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

ANSWER 7:

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

QUESTION 8:

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

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

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

ANSWER 8:

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

QUESTION 9:

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

ANSWER 9:

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

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

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

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

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

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

QUESTION 9a:

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

ANSWER 9a:

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

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

QUESTION 10:

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

ANSWER 10:

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

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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

QUESTION 1:

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

ANSWER 1:

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

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

QUESTION 2:

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

ANSWER 2:

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

QUESTION 3:

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

ANSWER 3:

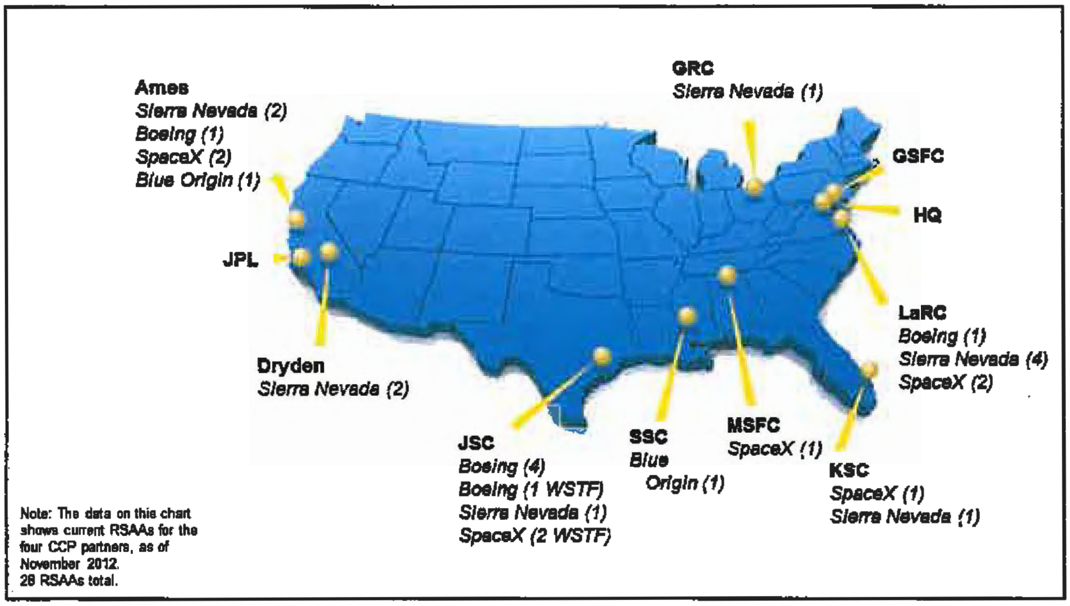
NASA published its draft evaluation criteria for the next phase of the Commercial Crew Program in July in a draft Request for Proposals, which can be accessed online. The final RFP with the official evaluation criteria is planned to be released in October.

QUESTION 4:

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

ANSWER 4:

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



QUESTION 5:

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

ANSWER 5:

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

QUESTION 6:

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

ANSWER 6:

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

QUESTION 7:

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

ANSWER 7:

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

Assumptions on implementation approach and the asteroid capture process drove cost estimates for the Keck study concept. NASA is using a set of reference Level 1 requirements for the current concept study to determine technical and programmatic feasibility. This set includes technical performance requirements and a cost cap requirement, which provides flexibility to manage cost and risk as part of the effort. NASA's goal is to develop and implement the robotic asteroid redirect mission for well under the Keck team's $2.6B estimate. The original Keck study cost estimate and the initial NASA analysis and cost estimates both examined the robotic redirect mission element and related mission operations, and neither included the crew exploration and sampling segment of the mission. The Keck study included the cost of the launch vehicle, while NASA estimates will address the cost of the launch vehicle separately from the rest of the robotic redirect mission element, as the vehicle choice follows mission definition. In addition to the concept currently under analysis, we are also looking at other mechanisms and mission systems, including a planned external call for ideas and discussions with potential U.S. and international partners. NASA is committed to finding a concept that is both technically and programmatically feasible. The actual cost will be reflected in future budget submits.

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

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
"An Overview of the National Aeronautics and Space Administration
Budget for Fiscal Year 2014"
Questions for the Record, The Honorable Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration (NASA)
Questions submitted by Rep. Bill Posey

QUESTION 1:

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

ANSWER 1:

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

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

These assumptions drove cost estimates for the Keck study concept. NASA is using a set of reference Level 1 requirements for the current concept study to determine technical and programmatic feasibility. This set includes technical performance requirements and a cost cap requirement, which provides flexibility to manage cost and risk as part of the effort. NASA's goal is to develop and implement the robotic asteroid redirect mission for well under the Keck team's $2.6B estimate. The original Keck study cost estimate and the initial NASA analysis and cost estimates both examined the robotic redirect mission element and related mission operations, and neither included the crew exploration and sampling segment of the mission. The Keck study included the cost of the launch vehicle, while NASA estimates will address the cost of the launch vehicle separately from the rest of the robotic redirect mission element, as the vehicle choice follows mission definition. In addition to the concept currently under analysis, we are also looking at other mechanisms and mission systems, including a planned external call for ideas and discussions with potential U.S. and international partners. NASA is committed to finding a concept that is both technically and programmatically feasible.

QUESTION 2:

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

ANSWER 2:

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

Specifically the two deliverables/gates are defined as:

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

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

QUESTION 3:

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

ANSWER 3:

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

QUESTION 4:

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

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

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

ANSWER 4:

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

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

NASA supports a robust public outreach effort that recognizes the importance of disseminating information, informing and educating a variety of external audiences, and inspiring new generations of explorers. As a result of Sequestration and a significantly reduced funding level for FY 2013, the Agency implemented a review of all public outreach efforts whose goal is to reach out to external and internal stakeholders and the public concerning NASA, its programs, and activities. Given the significant financial constraints, it was prudent for the Agency to review expenditures that were not directly related to mission safety, operations, and development.

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

Senate Commerce Committee Hearing

"Securing Our Nation's Transportation System: Oversight of the Transportation Security Administration's Current Efforts"

Senator Amy Klobuchar

Questions for the Record

Questions for Mr. William H. Gerstenmaier, Associate Administrator, Human Exploration and Operations (NASA)

Question 1: NASA relies upon a network of private partners across America to provide much of the hardware necessary for manned space flight. Those firms need long term certainty to be able to maintain a skilled workforce.

Are you concerned that potential cuts to the Orion program could jeopardize the nation's leadership in manned spaceflight?

Answer 1: The development of the Orion crew vehicle, heavy-lift Space Launch System (SLS), and enabling Exploration Ground Systems (EGS), as well as the commercial crew program, are maintaining the Nation's leadership in human spaceflight. Together, Orion, SLS, and EGS constitute the next critical step on the path to human deep space exploration. The FY 2014 President's Budget Request supports the funding necessary for these activities to maintain the Exploration Flight Test-1 (EFT-1), Exploration Mission-1 (EM-1), and Exploration Mission (EM-2) launch dates of 2014, 2017, and 2021, respectively. The Orion Program, including EFT-1 flight test preparation, provides experience and benefits to America's industrial base and supply chains. The industrial contractors and facilities involved with EFT-1 and the teams they employ, are gaining important experience, ensuring that the industrial base is exercised in accomplishing a spaceflight mission ahead of the 2017 EM-1 launch, the first launch of the Orion on the SLS.

Question 2: Administrator, as you may know, Minnesota is a leader in the medical device industry. A surprising number of the technologies used in the construction of medical devices were developed by NASA in pursuit of manned space flight.

Could you talk about the spillover effect you see across America that continued investment in NASA will yield?

Answer 2: The benefits of NASA research are all around us: Knowledge provided by weather and navigational spacecraft; millions of passengers and packages traveling safely by air every day; efficiency in ground and air transportation; super computers; solar- and wind-generated energy; the cameras in many cell phones; biomedical technologies such as advanced imaging and infant formula; and the protective gear that keeps our military, firefighters, and police safe have all benefitted from the Nation's investments in aerospace technology.

Over 90 percent of the infant formula sold around the world contains a specific nutrient discovered by NASA during plant growth experiments for long duration space flight.

Over 75 percent of the cell phone cameras today operate on a device called the CMOS, camera-on-a-chip that was designed by a NASA engineer Eric Fossum working on cameras for deep space imaging.

NASA is now creating a future in space exploration that was unimaginable just decades ago. Exciting advances, like solar electric propulsion for robotic missions, the Mars Science Laboratory, new Earth-observing satellites, and the James Webb Space Telescope underscore the importance of today's investment in space technology for tomorrow's discoveries and accomplishments.

To make these incredible technologies come to life, NASA researchers, engineers, and contractors often work alongside our many partners in industry and academia. These partnerships don't just further our missions; they also create a large number of spinoff technologies with tangible benefits that are making an impact on our lives today.

From life-saving shelters to innovations that protect the environment to components that are making commercial space transport possible, technology transfer represents a core part of NASA's mission and identity. It ensures that what we do each and every day for space and aerospace delivers the greatest benefit to the public.

You can learn more about commercialized NASA technologies at: spinoff.nasa.gov.

QUESTIONS FOR THE RECORD
THE HONORABLE LAMAR SMITH (R-TX)
U.S. House Committee on Science, Space, and Technology
STEM Education: The Administration's Proposed Re-Organization
Tuesday, June 4, 2013

1. **The National Science and Technology Council's Committee on STEM Education (CoSTEM) was required by the 2010 COMPETES Act to coordinate STEM education activities across federal agencies. CoSTEM has been working on the inventory of federal STEM programs and the 5-year Strategic Plan for a number of years. What was the role of CoSTEM in the development of the proposed reorganization of federal STEM programs? Did members of CoSTEM provide direct input on programs selected for consolidation? Please describe the process that led to the proposed reorganization and how it was similar to or different from the process used by CoSTEM.**

Guided by the aims articulated in CoSTEM's December 2011 STEM-education inventory, its February 2012 Progress Report, and subsequent pre-final drafts of the 5-year Strategic Plan—as well by the President's desire to re-organize STEM-education programs for greater coherence, efficiency, ease of evaluation, and focus on his highest priorities—the Executive Office of the President (EOP) recommended, and the President accepted, a FY 2014 Budget Request for STEM education that would increase the total investment in STEM-education programs by 6 percent over the 2012 appropriated level while reducing the number of programs spread across the 14 CoSTEM agencies from 226 to 110.

The draft 5-year Strategic Plan developed by CoSTEM informed the priority areas around which to focus the reorganization. By reorganizing and realigning resources around these priority areas, the proposed framework and related initiatives at each of the lead agencies are intended to improve the delivery of STEM education in each of these core areas.

Individual members of CoSTEM did not provide direct input in the EOP-led 2014 Budget formulation process, although the CoSTEM agencies participate annually in the budget formulation process within the Executive Branch. In formulating the STEM-education reorganization proposals contained in the President's 2014 Budget, CoSTEM's deliberations and documents were important inputs to the EOP-led process. The Administration actively sought input from CoSTEM agencies on program consolidations, eliminations, and new initiatives through the 2014 Budget process and coordinated discussions on implementation among the CoSTEM agencies to try to ensure that the proposed initiatives address the needs and goals of agencies with eliminated programs.

The CoSTEM will play a key role in developing transition plans and in managing, monitoring, and improving these reorganization initiatives.

2. **The Administration proposes to redirect funding from certain federal STEM education activities to the National Science Foundation, the Department of Education, and Smithsonian Institution. These agencies would become lead agencies for STEM activities. What institutional support, staffing requirements, and legal authority are needed for the lead agencies to take on their new roles as proposed by the reorganization?**

The institutional support and staffing requirements for the lead agencies to take on their new roles are provided for in the FY 2014 budget requests of the National Science Foundation (NSF), the Department of Education (ED), and the Smithsonian Institutions (SI). All agencies involved in the STEM education reorganization proposal have indicated to the Executive Office of the President that they will be able to take on their new roles upon approval of the proposal, and that none are significantly limited by legislative authority.

QUESTIONS FOR THE RECORD
THE HONORABLE RANDY NEUGEBAUER (R-TX)
U.S. House Committee on Science, Space, and Technology
STEM Education: The Administration's Proposed Re-Organization
Tuesday, June 4, 2013

1. **I am concerned that the proposed re-organization could threaten existing public-private partnerships in STEM education. According to an analysis by the Congressional Research Service (CRS), eight programs identified for consolidation require partnerships and 19 encourage them. What are you doing to estimate the total cost of these proposed reductions? What efforts were made to determine the extent to which schools, businesses, states, and non-profit organizations are financially and substantively integrated into particular federal STEM education programs? How have you attempted to determine the effects of these changes on local communities?**

Answer: I share your appreciation of the importance of public-private partnerships in STEM education. Partnerships are an important part of the Administration's efforts to improve STEM education. As Dr. Holdren stated in his testimony at the hearing, the President has set ambitious but achievable goals and challenged the private sector. For example, the President announced the goal to prepare 100,000 excellent STEM teachers in his 2011 State of the Union Address. Answering this call to action, over 150 organizations, led by the Carnegie Corporation of New York, formed a coalition called 100Kin10. Members of the coalition have made over 150 commitments to support STEM teacher preparation, and raised over $30M in funds. Additional examples of this all-hands-on-deck approach to challenging companies, foundations, non-profits, universities, and skilled volunteers include Change the Equation, US2020, and increasing the reach of the Advanced Placement (AP) program for children in military families.

The importance of partnerships is recognized in the reorganization proposal. The lead agencies will continue to make use of partnerships. For example, in P-12 teaching and learning the ED's STEM Innovation Networks proposals will support school districts in partnerships with institutions of higher education, Federal agencies and their facilities and staff, non-profit organizations, museums, businesses, and other partners to provide rich STEM learning experiences. In another example, SI will facilitate partnership building as part of its proposed leadership role in informal STEM education.

Although there are proposed reductions for certain programs in the 2014 Budget, the overall Federal STEM education effort would expand. The proposed reorganization, when combined with the 2014 Budget's proposal to increase Federal STEM education investments by 6 percent compared to the 2012 funding level to $3.1 billion, is intended to reach more students, teachers, researchers, schools, post-secondary institutions, and others than the current fragmented system while sustaining and building on the Federal government's success in supporting public-private partnerships in STEM education. In addition, the Administration and lead agencies are working with the other CoSTEM agencies to fully understand transition and implementation issues facing each agency and to ensure that the reorganization and new framework preserve core functions of eliminated programs.

2. Many of the programs affected by the proposed re-organization serve certain constituencies (e.g., students, teachers, researchers) who may be directly affected by the proposed changes. What efforts have been taken to predict and mitigate the impact of these changes on the constituencies

they serve? Can you please provide me with an estimate of how many people might be affected? Have you determined the number of job reductions that will take place as a result of the proposal?

Answer: The ED, NSF, and SI are working with their CoSTEM partner agencies to address transition issues such as staffing and continuation awards in order to mitigate the impact of the proposed reorganization on students, teachers, schools, and others affected by the transition of functions and activities. For example, ED is working with agencies that serve P-12 functions to identify connections with its STEM Innovation Networks proposal, as well as with existing P-12 STEM investments at ED and other CoSTEM agencies, to identify and continue best practices, and to use agency input to help develop program priorities. NSF is working with agencies with graduate fellowship programs to establish a mechanism for ongoing input on national and agency needs for STEM workforce. SI is working with all CoSTEM agencies to identify existing high-quality products and on-line resources, to identify best practices, and to establish knowledge-transfer systems. The other CoSTEM agencies are making recommendations on how to best engage with the above three agencies to utilize their expertise and experience in identifying continuation award issues and in developing staffing plans to facilitate knowledge transfer. The CoSTEM will play a key role in developing transition plans and in managing, monitoring, and improving these strategies.

The core goal of the proposed reorganization is to reach more students and more teachers more effectively. The proposed reorganization, when combined with the 2014 Budget's proposal to increase Federal STEM education investments by 6 percent compared to the 2012 funding level to $3.1B, is intended to reach more students, teachers, researchers, schools, post-secondary institutions, and others than the current fragmented system. The Administration has not analyzed the net employment impacts of the STEM education reorganization proposal as a whole nor the combined reach of the proposed STEM-education portfolio compared to the current one. The current fragmented approach to investing in STEM education has made it difficult to ensure that Federal efforts are coherent, strategic, and leveraged for greatest impact. By reorganizing and realigning resources, the proposal facilitates greater investment in rigorous evaluation and evidence-building strategies so that the Federal government will be better able to document how many people are affected by Federal STEM education programs, and how.

QUESTIONS FOR THE RECORD
THE HONORABLE RALPH HALL (R-TX)
U.S. HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
STEM Education: The Administration's Proposed Re-Organization
Tuesday, June 4, 2013

1. The Space Grant program has operated since 1988 according to the same practice-every five years states submit 5-year plans to NASA that are competitively reviewed. NASA then makes a 5-year award to the states based on the funding levels provided by Congress. NASA makes annual increments under the approved 5-year plans to a lead consortia institution in the state, subject to annual performance reviews. The Space Grant consortia then funds state projects and activities based on a merit review of proposals. For the last four years Congress has appropriated $40 million annually to the Space Grant Program. In FY 2012, NASA changed course from its standard operating procedures and did not fully fund all of the states according to the 5-year plans and the money appropriated by Congress. Rather, NASA took the additional money Congress appropriated to the program beyond the President's budget request and forward-funded 28 states for FY 2013. Space Grant Program stakeholders feel that the decision not to provide augmentation grants left states without their full funding in FY 2012.

What happened to the funding and when can states expect to receive the funding that Congress intended for them based on appropriations? What were the criteria used to determine which states were forward-funded for FY 2013 using FY 2012 appropriated dollars? Were those criteria clearly spelled out to all consortia members?

Additionally, the Space Grant offices are being told that a portion of future Space Grant dollars will be allocated by NASA Headquarters and decisions centralized in Washington, not by the consortia operating in the states. Why did you make this change to the program without consulting Congress?

Answer: In 1989, The National Space Grant College and Fellowship Program (Space Grant) was enacted by Congress (Public Law 100-147) and established under Title II of the NASA Authorization Act. NASA implements the Space Grant program in all 50 states, the District of Columbia, and the Commonwealth of Puerto Rico through 52 university-based Space Grant consortia. These consortia form the basis for the national network of colleges and universities, industry partners, State and local government agencies, other Federal agencies, museum and science centers, and nonprofit organizations, all of whom are stakeholders in science, technology, engineering and mathematics (STEM) education and training. The national network currently comprises 1,014 affiliates, of which 672 (66 percent) are institutions of higher education nationwide, and serves 14,894 direct participants (STEM engagement ≥160 hours and/or ≥$5,000) by leveraging NASA funds and providing cost share. Space Grant consortia annually fund fellowships and scholarships to support the participation of students and faculty in authentic NASA-related research, emphasize diversity of participants, institutions and human resources, support curriculum enhancement, and the communication of the benefits of STEM disciplines through public engagement activities in their states.

Space Grant's 2010-2015 objectives are linked to NASA Office of Education's current areas of emphasis:

- Authentic, hands-on student experiences in science and engineering disciplines.
- Engaging middle school teachers in hands-on curriculum enhancement capabilities using NASA-specific content.

- Summer opportunities for secondary students on college campuses with the objective to increase enrollment in STEM disciplines and STEM careers.
- Community Colleges- developing new relationships as well as sustaining and strengthening existing institutional relationships.
- Aeronautics research- research in traditional disciplines; research in areas that are appropriate to NASA's unique capabilities; research that directly addresses the Next Generation Air Transportation System (NextGen).
- Environmental Science and Global Climate Change- research and activities to better understand Earth's environments.
- Diversity of institutions, faculty and students.
- Enhancing the capacity of institutions to support innovative research infrastructure activities to enable early career faculty to focus their research toward NASA priorities.

Current Grant Cycle

NASA Space Grant Timeline Summary

	2010	*2011*	*2012*	*2013*	*2014*	*2015*
Current Cycle	*Year 1 of Base* *Augmentations* *CDC Competition*	*Year 2 of Base* *Augmentations*	*Year 3 of Base* *Forward Funding*	*Year 4 of Base* *Targeted Competitions*	*Year 5 of Base* *(end of current grant cycle)*	
Future Plan					*Qtr 1: Solicitation preparation* *Qtr 2: Solicitation Release* *Qtr 3: Selections*	*Qtr 1: Start of new awards (pending fund availability)*

In FY 2010, NASA established new awards for the 52 Space Grant consortia based upon the President's Budget Request and the projected outyear requests. The awards support multi-year grants to be funded over a five year period (FY 2010-FY 2014). Funded at two levels, there are 35 "designated" awards at $575,000 annually and 17 "non-designated" awards at $430,000 annually. These are referred to as "Base Awards." Over a 5-year period, the higher funded consortia would receive $2.875M in total base awards ($575K X 5 years) and the lower funded consortia would receive $2.150M in total ($430K X 5 years) base awards. The anticipated total grant awards for the 5-year period would be $137.175M.

Fiscal Year 2010

- President's Budget Request: $28.4M
- Appropriated Funds for Space Grant: $45.6M
  - Congressional language – *House Conference Report 111-366, National Space Grant College and Fellowship program.—For this program, the Committee recommends*

$45,600,000 to fund 42 states or jurisdictions at $900,000 each and 10 states or jurisdictions at $700,000 each.

- Funding Actions:
  - NASA obligated $27.563M toward base awards. NASA also issued solicitations and released $13.949M in funding for one-year augmentation awards, and a targeted consortium development opportunity.
    - Augmentation award totals: Designated: $270,000; Non-Designated: $230,000
  - Remaining funds supported Evaluation and Program Accountability ($1.791M), support service contracts ($2.28M), and travel ($.017M).

Fiscal Year 2011

- President's Budget Request: $27.7M
- Appropriated Funds for Space Grant: $45.6M
  - Congressional language – Full-Year Continuing Resolution; see FY 2010 language
  - Amount subsequently reduced by $1.16M for mandatory rescission
- Funding Actions:
  - NASA obligated $33.005M toward base awards. NASA also issued a solicitation and released $10.315M in funding for one-year augmentation awards.
    - Augmentation award totals: Designated funded: $215,000; Non-Designated: $185,000
  - Remaining funds (after mandatory rescission) included travel ($.003), and support service contracts ($1.005M).

Fiscal Year 2012

- President's Budget Request: $26.6M
- Appropriated Funds for Space Grant: $40.0M
  - Congressional language – House Conference Report 112-284: Education – *For necessary expenses, not otherwise provided for, in carrying out aerospace and aeronautical education research and development activities....$138,400,000, to remain available until September 30, 2013, of which $18,400,000 shall be for the Experimental Program to Stimulate Competitive Research and $40,000,000 shall be for the National Space Grant College program.*
- Funding Actions:
  - NASA obligated $36.714M toward base awards and did not issue any augmentations or targeted opportunities.
    - Given anticipated budget reductions based upon the President's Budget Request for FY 2013 and the need to reduce the amount of FY 2012 carryover funds, NASA made the decision to forward fund (as much as possible) awards for Year 4 of 5 for the consortia in order to insure that the Base Awards continued to be fully covered.
    - Forward-funding decisions were based upon consortium performance over the first three years of the grant period. Consortia receiving forward-funding consistently exceeded proposed goals and objectives stated in their original proposals and consistently achieved their diversity measures.
  - Remaining funds supported administrative costs ($.288M), travel ($.016M), Evaluation and Program Accountability ($2.300M), civil service labor ($.003M), and support service contracts ($.679M). The remaining balance ($.467M) was used to support a portion of year 4 base award.

Fiscal Year 2013

- President's Budget Request: $24M
- Appropriated Funds: 37.2M

- Congressional language – *Full year Continuing Appropriations: Aerospace Research and Career Development (ARCD).--$40,000,000 is for the National Space Grant College program, and $18,000,000 is for the Experimental Program to Stimulate Competitive Research (EPSCoR). Language from the Senate report regarding the distribution of Space Grant funding to states and jurisdictions is not adopted.*

- Funding actions: NASA intends to obligate $12.495M toward base awards. NASA issued a solicitation and intends to obligate $5.0M toward a one-year targeted funding opportunity to support undergraduate STEM retention, and K-12 STEM Educator recruitment and retention. Other obligations include, Program Accountability and Evaluation at($2.190M), Support Service Contracts ($.900M) and an external NRC evaluation estimated at ($1.5M)
  - Targeted solicitation released in first quarter of fiscal year 2013. Anticipate award decisions in August/September 2013.

NASA anticipates using additional funds above base awards and current targeted solicitation (approximately $9.7M) to offer further targeted opportunity grants that focus on CoSTEM and the Agency's priorities: Educator Professional Development, STEM Engagement, Institutional Engagement, and NASA Internships, Fellowships, and Scholarships.

None of the administrative decisions made in the implementation of Space Grant funds have been contradictory to Congressional guidelines; and the Associate Administrator for Education has directly addressed consortia leadership multiple times via teleconferences and the annual Directors meeting for Space Grant, regarding the decisions described above.

Fiscal Year 2014

- President's Budget Request: $24M
- Funding actions:
  - NASA intends to obligate $16.56M toward base awards.
  - In addition, funds are planned to be used for administrative costs, travel, STEM consolidation, evaluation and program accountability, civil service labor, and support service contracts ($7.44M)
  - Determination regarding utilization of any additional funds will be made in alignment with Administration and Agency priorities.

Fiscal Year 2015

- President's Budget Request: (TBD) Funding actions: Funds will be utilized to close any continuing actions from previous awards and in alignment with Administration and Agency priorities.
- Future preparation: NASA will release a new solicitation for the Space Grant program, for start in FY 15, which aligns with the Administration and Agency priorities.

QUESTIONS FOR THE RECORD
THE HONORABLE LARRY BUCSHON (R-IN)
U.S. House Committee on Science, Space, and Technology

STEM Education: The Administration's Proposed Re-Organization

Tuesday, June 4, 2013

1. NASA programs account for nearly half of the programs whose funding would be redirected to other agencies under the Administration's proposal. The policy of the NASA Science Mission Directorate has been to allocate at least 1 percent of each space mission's budget to education and public outreach activities. Is that policy effectively terminated with this proposal? Will Individual space missions, such as the Hubble Space Telescope or the MESSENGER probe of the planet Mercury, still be permitted and/or encouraged to engage in education and public outreach?

Answer: NASA remains committed to supporting education and public outreach activities for its portfolio of exciting missions of exploration and discovery.

Education content and efforts that are no longer funded by NASA will be reviewed by NSF, ED, and SI. Elements or activities that support the Administration's STEM reorganization goals will be considered for incorporation into the broader reorganization initiatives. NSF, ED, and SI are currently developing the guidelines and procedures for securing funds for education activities under these broader initiatives; once the process is established, NASA's Science Mission Directorate (SMD) will work closely with NASA's Office of Education to seek funding for evidence based education activities at the mission level. NASA will also work closely with the three lead agencies and other CoSTEM partners to ensure that the Agency's unique resources (workforce, innovative approaches, and facilities) remain available to help inspire students and support educators..

Although the current budget proposal alters the method of coordination of education and public outreach activities between SMD and the Office of Education, it does not alter the commitment to collaborate.

QUESTIONS FOR THE RECORD
HONORABLE EDDIE BERNICE JOHNSON (D-TX)
U.S. House Committee on Science, Space, and Technology

STEM Education: The Administration's Proposed Re-Organization

Tuesday, June 4, 2013

1. As part of the OSTP STEM Inventory, NASA reported a total of 62 STEM education programs in 2011. Of those, 54 programs would either be consolidated outside the agency or terminated or consolidated internally as part of the Administration's FY 2014 budget proposal. You were already undertaking significant efforts to improve the coordination and effectiveness of NASA's broad STEM portfolio long before the FY 2014 budget proposal was developed, including, as you indicated in your testimony, through some program consolidations. I remain concerned that the decisions made as part of the FY 2014 budget proposal were not based on your own internal deliberative process for improving NASA's STEM portfolio.

- **What actions, if any, has NASA taken since April 1, 2013 to begin implementing the 54 consolidations and terminations included in the FY 2014 budget proposal, including any terminations to current grants, any notices to grantees and potential grantees that no new awards will be made, and any relevant headquarters staff moved around or terminated?**

- **What similar actions, if any, did NASA take prior to April 1, 2013 (and since the 2011 inventory) with respect to any one of the 54 programs?**

NASA's Office of Education remains responsible for coordinating NASA's education efforts under the Administration's FY 2014 STEM reorganization proposal. NASA Education's vision is to advance high quality science, technology, engineering and mathematics (STEM) education using NASA's unique capabilities. NASA has held a number of briefings and discussions with its workforce and external partners on the proposed FY 2014 strategy. Furthermore, NASA has in place an **Education Coordinating Council** (ECC). The ECC includes representatives from all mission directorates, centers and Office of Education, serving as the Agency's senior decision-making body for strategic direction and planning related to education. Through the ECC, the Associate Administrator for Education has the ability to coordinate and direct a comprehensive portfolio of activities funded by the Office of Education and NASA Mission Directorates.

The ECC has met multiple times between April-June to discuss the Administration's proposed budget and reorganization guidance. No actions have been taken to a) terminate current grants, b) notify grantees and potential grantees that new awards will not be made, nor c) notify any relevant headquarters staff of reassignment or termination for FY 2014.

The Agency's education efforts will use evidence-based competitive processes to fund the best education and outreach programs within NASA. This includes executing a unified, systematic and standardized approach for data collection and performance assessment across NASA Education. NASA will align its STEM education investments with the federal strategic plans of the National Science and Technology Council's Committee on STEM Education (CoSTEM).

Content and efforts that are no longer funded by NASA will be reviewed by NSF, ED and SI. Elements or activities that support the STEM reorganization goals will be considered for incorporation into the broader reorganization initiatives. As part of this effort, NASA will work closely with the lead agencies and other CoSTEM partners to ensure that the Agency's unique resources (workforce, innovative approaches, and facilities) remain available to help inspire students and support educators.

Based on the reorganization guidance we received, NASA's proposed FY 2014 STEM Education Programmatic and Budget structure consists of two programs (Aerospace Research & Career Development Program and STEM Education and Accountability Program). Within those programs are four projects (Space Grant College and Fellowship Project (Space Grant), Experimental Program to Stimulate Competitive Research (EPSCoR), Minority University Research & Education Project (MUREP) and STEM Education and Accountability Projects). Additionally, three activities (Global Learning and Observations to Benefit the Environment (GLOBE), STEM Interagency Coordination, and STEM Facilitation) are proposed. Listed below is an illustration of our programmatic and budget structure:

Aerospace Research & Career Development Program

- Space Grant College and Fellowship Project
- Experimental Program to Stimulate Competitive Research (EPSCoR)

STEM Education and Accountability Program

- Minority University Research & Education Project (MUREP)
- STEM Education and Accountability Projects
    - GLOBE
    - STEM Facilitation
    - STEM Interagency Coordination

NASA's ECC made decisions during FY 2012 that were implemented in FY 2013, with FY 2013 designated as a transition year towards a reorganized and more strategic education portfolio positioned to more effectively address the Administration's STEM priorities and the anticipated direction framed in the progress report of the CoSTEM strategic plan. We decided that the best way to focus more resources on high priority activities within a highly constrained budget was to reduce or consolidate lower priority activities. Twenty-seven activities were initially identified within the Office of Education. Sunsetting of activities was proposed as a natural element of a project's life cycle (e.g., end of performance period).

This one-year transition period allowed for deliberate planning to minimize any disruption of service to external customers and internal coordination by program managers in the consolidation and sunsetting of activities. No cooperative agreements were cancelled under this process. Furthermore, at this time, cooperative agreements at the end of performance period (FY 2013) are proceeding with transition and close-out actions. In some instances existing cooperative agreements may have been re-scoped at the beginning of FY 2013 as a step in the transition process and funding levels reduced to align with strategic program direction. Our own internal deliberative process for improving NASA's STEM education portfolio was used to make strategic decisions associated with the FY 2014 reorganization proposal.

2. **What steps can be taken now to begin implementing the 5-year strategic plan that do not involve moving money or redirecting programs between/among agencies? That is, what new interagency collaborations can be established and new capacity built at the currently designated lead agencies that don't require collaborating agencies to reduce support for their own portfolio of STEM education programs, at least not yet?**

    - **What specific steps can NASA take to increase collaboration in the short term?**

The STEM 5-year Strategic Plan prepared by the Committee on STEM Education (CoSTEM) of the National Science and Technology Council (NSTC) which I co-chair with Cora Marrett, Acting Director of the National Science Foundation, lays out a strategy to leverage Federal agency assets and expertise to make progress on the national priority areas of STEM education: improve STEM instruction; increase and sustain youth and public engagement in STEM; enhance the STEM experience of undergraduate students; better serve groups historically under-represented in STEM fields; and design graduate education for tomorrow's STEM workforce. The Plan aligns in many ways with the goals established in the President's 2014 Budget proposal, but the Plan has been developed by agency representatives and agreed to by agency leadership and therefore implementation can proceed absent any other action.

The Plan outlines an updated STEM-education coordination approach with lead and collaborating agencies to leverage capabilities across agencies to maximize the impact of Federal STEM education investments. The Plan includes implementation roadmaps describing objectives and strategies to achieve the outlined goals. The CoSTEM agencies have already started making plans for implementation and will work together through the CoSTEM structure, as described in the implementation roadmaps, and through additional interagency activities, as necessary, to reach the goals described in each of the priority areas.

Building new capacity to enable NSF, ED, and SI to fulfill their responsibilities as lead agencies according to the Strategic Plan's vision will require some new resources, as proposed in the 2014 Budget. Additionally, through the process of developing the Federal STEM Inventory some agencies have already identified opportunities for internal consolidation of STEM education programs and other ways of making the most effective use of existing resources; these efforts should be encouraged, not restricted.

NASA actively engaged with NSF, ED, SI, and other agencies in the review and completion of the CoSTEM five-year strategic plan. NASA continues to regularly participate in CoSTEM and FC-STEM meetings and to help facilitate the implementation steps of the five-year strategic plan. In addition, NASA offered an initial assessment of the types of assets that seemed to align with the initiatives each lead agency proposed under the STEM reorganization through direct exchanges with them in April, and has offered to host an interagency meeting on behalf of ED in August.

NASA has suggested new collaboration and workforce models for consideration to the three lead agencies in advance of the development of implementation subcommittees during summer 2013 to address the CoSTEM priority areas. Examples of a new collaboration models are the establishment of interagency agreements with reimbursable work (Reimbursable Work for Federal Agencies under the Economy Act; 31 U.S.C. § 1535, Economy Act; the Economy Act provides authority for all Federal agencies to engage in interagency reimbursable activity within certain constraints) and NASA's Space Act Agreement (SAA) authority in the short term. NASA and ED are currently completing an SAA with reimbursable work for pilot (Aug 2013-Nov 2014) under ED's 21st Century Community Learning Centers. The lessons learned under this reimbursable work may position NASA to develop further collaborations with ED and similar opportunities with NSF and SI, linking existing activities across agencies to develop new capacities without the necessity of significant redirection of program priorities between/among agencies.

NASA has also offered ideas on looking closely at a flexible workforce model, whereby the skill sets/expertise across the civil servants of science mission agencies and support services could be available NSF, ED and SI. These ideas include IPAs (e.g., one-year assignments of NASA personnel to lead agencies), details in place (e.g., personnel remains at home institution performing targeted work associated with lead agency/CoSTEM priorities with occasional travel to Washington, DC for key milestones/meetings), and short-term details to lead agencies with rotating professionals.

3. One of my concerns with the reorganization proposal in the FY 2014 budget is that it isn't vetted at all with any of the non-federal partners that help make federal STEM investments successful. It is equally troubling that the five-year strategic plan doesn't say very much about engaging the stakeholder community, except in the broadening participation priority.

- **Does NASA plan to seek input from non-federal stakeholders as you develop and, as necessary, revise NASA's part in implementing the CoSTEM strategic plan? If so, how will NASA seek such input?**

Answer: Although CoSTEM as an entity will not be seeking formal public input from non-Federal stakeholders as the implementation of the Strategic Plan moves forward, the CoSTEM agencies will continue to engage with non-Federal stakeholders in ongoing dialogue, consultation, and partnership in advancing the goals of the Strategic Plan and in the operations of Federal STEM-education programs. The 5-Year Strategic Plan is not intended to be a static document; the Plan's preliminary implementation roadmaps for each of the priority areas are presented with the full expectation that they will be revised over the next five years and supplemented by more detailed roadmaps designed by the Administration and the CoSTEM agencies over the coming months, built on communication and outreach with stakeholder communities. The Strategic Plan commits CoSTEM to assisting in this process. I anticipate that there will be a variety of approaches among the 14 CoSTEM agencies for engaging stakeholders, as is the case right now for how agencies work with stakeholders on their current STEM-education portfolios.

The Associate Administrator for Education has addressed multiple stakeholder communities on the STEM reorganization since April 2013 and highlighted the CoSTEM strategic plan and its implications since its official release at the end of May 2013. The Associate Administrator for Education has used a variety of communication methods (e.g., teleconferences, videoconferences, and Webex) to engage the entire NASA Education community, including the extensive network constituting NASA's Science Mission Directorate (SMD) Education and Public Outreach Forums. Feedback from these communities of practice has been incorporated into the strategic discussions associated with the development of NASA Education's FY 2013 and FY 2014 plans.

Additionally, the following stakeholder communities have been directly engaged by the Associate Administrator for Education in determining NASA's part in implementing the CoSTEM strategic plan:

- Aerospace Industries Association
- American Institute for Aeronautics and Astronautics
- Universities Space Research Association
- National Space Grant Alliance
- National Science Foundation's National Science Board
- American Astronautical Society
- National Science Teachers Association
- Space Telescope Institute (Johns Hopkins University)

More focused and targeted engagement with non-federal stakeholders is being considered as the implementation phase of the CoSTEM plan begins. A few near term methods include:

- Hosting virtual meetings (e.g., Webinars, teleconferences, and videoconferences) with NASA grantees and cooperative agreement recipients
- Independent third parties (e.g., Board of Science Education/National Academies/American Association for the Advancement of Science) host expert meetings or series of public workshops to provide a neural ground for stakeholder input.

It is anticipated that there will be a variety of approaches among the 14 CoSTEM agencies for engaging stakeholders, as is the case right now for the agencies in working with stakeholders on their current STEM-education portfolios.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEES ON OVERSIGHT AND ENERGY

"Green Buildings – An Evaluation of Energy Savings Performance Contracts (ESPCs)"

QUESTIONS FOR THE RECORD

Dr. Woodrow Whitlow, Jr., Associate Administrator
Mission Support Directorate, National Aeronautics and Space Administration

Questions submitted by Chairman Paul Broun and Chairman Cynthia Lummis:

1. Are all NASA Centers engaged in ESPCs, and if not, why not?

   Response: NASA has utilized ESPCs at six of ten Field Centers. The following Centers have not used ESPCs:
   - Dryden Flight Research Center, CA – Pursued an ESPC project under a Department of Energy (DOE) ESPC master contract but cancelled the effort prior to awarding a task order due to limited resources to develop, administer, and maintain the project over the full contract term.
   - Langley Research Center, VA, and Stennis Space Center, MS – Obtain benefits similar to ESPCs by using Utility Energy Services Contracts (UESCs).
   - Marshall Space Flight Center, AL – Consistently implements energy conservation measures through conventional contracts.

2. Does NASA have staff trained in ESPCs or does the Agency rely on FEMP staff primarily to guide NASA employees through the ESPC process?

   Response: Both. NASA has procurement and technical staff trained in ESPCs, and also utilizes assistance from Federal Financing Specialists and Project Facilitators contracted to DOE Federal Energy Management Program (FEMP) to develop task orders.

   a. Overall, has FEMP been helpful throughout the implementation and life of ESPCs? If not, how could their interactions improve?

   Response: Yes, FEMP has helpfully supported NASA ESPC efforts through providing ESPC master contracts, training, assisting task order development, and monitoring project performance during the post-installation performance period.

   b. When a contract ends early, do you find that NASA staff is sufficiently trained to provide maintenance of energy efficiency improvements that have been made?

   Response: Yes, in uncommon cases where NASA completed an ESPC project's loan repayment prior to the full contract term, our facilities operations and maintenance personnel were sufficiently trained to maintain systems that received ESPC energy efficiency improvements.

3. How often does NASA engage in contracts with other firms that offer energy efficiency improvements that are not included on the DOE's pre-approved list of ESCOs? Can you name a potential situation where NASA would prefer to work with an outside firm, and if so, what is the reasoning?

   Response: DOE maintains a Qualified List of ESCOs; DOE competes and awards ESPC master contracts to a subset of the companies on this list. Outside of DOE's ESPC master contracts, Agencies can also directly contract for ESPCs with companies on the DOE Qualified List of ESCOs. NASA has only engaged in ESPCs through contracts with ESCOs on the DOE Qualified List of ESCOs.

   Since NASA began using ESPCs in 1999, the Agency has engaged in ESPCs through four contracts outside DOE's ESPC master contracts: Two NASA contracts established in 1999 and last utilized in 2003, one United States Air Force contract including co-located NASA facilities established in 2000 and completed loan repayment in 2012, and one NASA Federally Funded Research and Development Center (FFRDC) prime contractor subcontract established in 2007 and still utilized. The first three contracts were under development while DOE developed its original ESPC master contracts. In the FFRDC example, NASA's contract with the prime contractor includes energy management requirements, and the prime contractor utilizes an ESPC subcontract as one means of fulfilling the energy management requirements.

4. What are the key advantages and limitations of ESPCs, and what suggestions do you have to improve the ESPC process – either through legislation or administrative regulation?

   Response: ESPCs enable NASA to implement energy and water efficiency upgrades in funding circumstances where it could not otherwise be accomplished. A potential area for continually improving ESPCs includes requiring full transparency of all cost and revenue streams in ESCO proposals. This improvement would benefit both DOE and non-DOE ESPCs.

Questions submitted by Rep. Randy Hultgren (R-IL):

1. Has NASA experienced or noted any disadvantages when partaking in the ESPC program?

   Response: Yes. Developing, administering, and maintaining ESPCs is more complex than implementing projects under conventional Federal government contracts. This complexity arises from contracting for a project with financing repaid from cost savings throughout a contract term of up to 25 years, and from measurement and verification of guaranteed cost savings throughout the contract term.

   a. If so, what have those been and how often have they occurred?

   Response: Smaller NASA sites with very constrained personnel resources find it difficult to implement an ESPC project—even under DOE ESPC master contracts. The Agency has experienced a site that pursued a project under a DOE ESPC master contract but cancelled the effort prior to awarding a task order due to limited resources to develop, administer, and maintain the project over the full contract term. NASA has also experienced a site that successfully implemented an ESPC project under a DOE contract, but with the impact of ESPC coordination consuming nearly all of the site's energy management personnel resource capacity.

   b. Have these disadvantages dissipated over the years as the program has evolved?

   Response: No, it remains challenging for personnel to conduct full-scale ESPC at smaller sites.

   c. How can the program be improved to eliminate such weaknesses?

   Response: DOE developed ESPC ENABLE to provide a streamlined mechanism for very small sites to implement a limited selection of energy conservation measures. This could prove helpful for agencies with such needs.