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EXTERNAL PERSPECTIVES ON THE FISCAL YEAR 2010 NASA BUDGET REQUEST AND RELATED ISSUES

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE AND AERONAUTICS

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

JUNE 18, 2009

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CONTENTS

June 18, 2009

	Page
Witness List	2
Hearing Charter	3

Opening Statements

Statement by Representative Gabrielle Giffords, Chairwoman, Subcommittee on Space and Aeronautics, Committee on Science and Technology, U.S. House of Representatives	16
Written Statement	16
Statement by Representative Ralph M. Hall, Minority Ranking Member, Subcommittee on Space and Aeronautics, Committee on Science and Technology, U.S. House of Representatives	17

Witnesses:

Mr. John C. Marshall, Member, Aerospace Safety Advisory Panel (ASAP)	
Oral Statement	17
Written Statement	19
Biography	23
Dr. Kenneth M. Ford, Chair, National Aeronautics and Space Administration Advisory Council (NAC)	
Oral Statement	24
Written Statement	25
Biography	30
Mr. Robert M. Hanisee, Chair, Audit and Finance Committee, NASA Advisory Council (NAC)	
Oral Statement	31
Written Statement	33
Biography	37
Dr. Raymond S. Colladay, Chair, National Academies' Aeronautics and Space Engineering Board (ASEB)	
Oral Statement	38
Written Statement	39
Biography	41
Dr. Berrien Moore III, Member, National Academies' Space Studies Board (SSB)	
Oral Statement	42
Written Statement	43
Mr. J.P. Stevens, Vice President for Space Systems, Aerospace Industries Association (AIA)	
Oral Statement	57
Written Statement	58
Biography	62
Discussion	62

Appendix: Answers to Post-Hearing Questions

Mr. John C. Marshall, Member, Aerospace Safety Advisory Panel (ASAP)	68
Dr. Kenneth M. Ford, Chair, National Aeronautics and Space Administration Advisory Council (NAC)	75

Page

Mr. Robert M. Hanisee, Chair, Audit and Finance Committee, NASA Advisory Council (NAC) 83

Dr. Berrien Moore III, Member, National Academies' Space Studies Board (SSB) 90

Mr. J.P. Stevens, Vice President for Space Systems, Aerospace Industries Association (AIA) 97

EXTERNAL PERSPECTIVES ON THE FISCAL YEAR 2010 NASA BUDGET REQUEST AND RELATED ISSUES

THURSDAY, JUNE 18, 2009

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

The Subcommittee met, pursuant to call, at 10:03 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Giffords [Chairwoman of the Subcommittee] presiding.

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON SPACE & AERONAUTICS
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, DC 20515

Hearing on

External Perspectives on the FY 2010 NASA Budget Request and Related Issues

June 18, 2009
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

WITNESS LIST

Mr. John C. Marshall
Member
Aerospace Safety Advisory Panel (ASAP)

Dr. Kenneth M. Ford
Chair
NASA Advisory Council (NAC)

Mr. Robert M. Hanisee
Chair
Audit and Finance Committee
NASA Advisory Council (NAC)

Dr. Raymond S. Colladay
Chair
National Academies' Aeronautics and Space Engineering Board (ASEB)

Dr. Berrien Moore III
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National Academies' Space Studies Board (SSB)

Mr. J.P. Stevens
Vice President for Space Systems
Aerospace Industries Association (AIA)

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HEARING CHARTER

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

External Perspectives on the Fiscal Year 2010 NASA Budget Report and Related Issues

THURSDAY, JUNE 18, 2009
10:00 A.M.—12:00 P.M.
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Purpose

On Thursday, June 18, 2009 at 10:00 a.m., the Subcommittee on Space and Aeronautics will hear from advisory and other stakeholder bodies on issues relevant to the National Aeronautics and Space Administration (NASA).

Witnesses:

Mr. John C. Marshall, Member, Aerospace Safety Advisory Panel (ASAP)

Dr. Kenneth M. Ford, Chair, NASA Advisory Council (NAC)

Mr. Robert M. Hanisee, Chair, Audit and Finance Committee, NASA Advisory Council (NAC)

Dr. Raymond S. Colladay, Chair, National Academies' Aeronautics and Space Engineering Board (ASEB)

Dr. Berrien Moore III, Member, National Academies' Space Studies Board (SSB)

Mr. J.P. Stevens, Vice President for Space Systems, Aerospace Industries Association (AIA)

BACKGROUND INFORMATION

Overview

The National Aeronautics and Space Administration (NASA), which was established in 1958, is the Nation's primary civil space and aeronautics R&D agency. The projected civil service workforce for FY09 is 17,900 employees. NASA has ten field Centers, including the Jet Propulsion Laboratory (JPL), a Federally Funded Research and Development Center (FFRDC). NASA conducts research and development activities in a wide range of disciplines including aeronautics, astrophysics, heliophysics, planetary science, Earth science and applications, microgravity research, and long-term technology development. NASA also operates a fleet of three Space Shuttles and is assembling and operating the International Space Station (ISS). NASA is undertaking an exploration initiative with the goals of developing a new human space transportation system for both low-Earth orbit and for missions beyond low-Earth orbit, returning American astronauts to the Moon by 2020, and carrying out a broad program of human and robotic exploration of the solar system. NASA also maintains a space communications network that supports both NASA missions and other federal agency requirements. As of 2007, the most recent date for which complete data are available, about 82 percent of NASA's budget was for contracted work. In addition, a number of NASA's scientific and human space flight activities involve collaboration with international participants.

The Committee held a hearing on May 19, 2009 at which time the NASA Acting Administrator, Mr. Christopher Scolese, presented NASA's FY 2010 budget request. Witnesses at today's hearing have been asked to identify the top priorities and issues that the Committee on Science and Technology should consider in upcoming multi-year NASA authorization legislation and any other matters they believe merit attention.

Budgetary Information

To put the FY10 budget request into context, NASA has been tasked with flying the Shuttle safely until the end of the decade and then retiring the Shuttle fleet; completing assembly of, operating, and utilizing the International Space Station; completing the development of a new Crew Exploration Vehicle/Crew Launch Vehicle by 2015; returning American astronauts to the Moon by 2020; and conducting a variety of challenging science and aeronautics programs. The *NASA Authorization Act of 2008* [P.L. 110–422] authorized an FY09 funding level for NASA of $20.21 billion; the FY09 NASA budget request was $17.61 billion and the appropriation for FY09 was $17.78 billion. In addition, The *American Recovery and Reinvestment Act* [P.L. 111–5] included $1 billion for NASA's Earth science, aeronautics, exploration programs, cross-agency support, and Inspector General. Recovery Act funds are to be expended by September 30, 2010. P.L. 110–422 is a one-year authorization for NASA; the Science and Technology Committee is planning to move a multi-year reauthorization of NASA later this year.

President's FY 2010 Request

NASA's proposed budget for FY10 is $18.7 billion, an increase of 5.1 percent over the enacted FY09 appropriation for NASA. The FY10 budget projection for NASA beyond FY10 is essentially flat through FY13. Attachment 1 summarizes the FY10 budget request and its five-year funding plan.

Attachment 2 compares the NASA budget plan that accompanied the *Vision for Space Exploration* introduced by President Bush in 2004 with the actual funds requested for NASA. As can be seen, previous budget requests for NASA have been significantly less (i.e., typically on the order of a half-billion dollars or more in the early years) than what was projected as being needed to carry out the Exploration initiative and NASA's other core missions. The cumulative shortfall over that period is in excess of $4 billion. The additional funding provided in the FY09 appropriation and the FY10 budget request help to redress that shortfall. However the FY10 budget request does not project growth for the NASA budget beyond FY10, and the disparity between the 2004 budget projections for FY 2011–2014 that the Agency was planning against and the budgets that are now being proposed through FY14 is shown in the chart. In addition, the impact of the budgetary shortfalls since 2004 has been exacerbated by the requirement to absorb the cost of the Shuttle's return-to-flight following the *Columbia* accident, the additional cost associated with the under budgeting of Shuttle transition and retirement that occurred in the FY05 budget plan, and the under budgeting of ISS program support that also occurred in the FY05 budget plan, which NASA indicates resulted in an unfunded lien against the Agency's budgets of about $6.5 billion through FY10.

House Appropriations Committee's Approval of CJS Subcommittee Recommendations

The Commerce, Justice, and Science (CJS) Subcommittee of the House Appropriations Committee held a markup of their fiscal year 2010 appropriations bill on June 4, 2009. The Subcommittee's funding recommendations for NASA in the bill were as follows:

Dollars in millions

	FY 09 Enacted	FY 10 Request	HAC/CJS FY 10 Markup	% Change between HAC/CJS FY 10 Markup and FY 10 Request
Science	4,503.0	4,477.2	4,496.1	+ 0.4
Aeronautics	500.0	507.0	501.0	-1.2
Exploration	3,505.5	3,963.1*	3,293.2	-16.9
Space operations	5,764.7	6,175.6	6,097.3	-1.3
Education	169.2	126.1	175.0	+38.8
Cross agency support	3,306.4	3,400.6	3,164.0	-6.9
Construction and environmental compliance	0.0	0.0	441.7	N/A (HAC Subcommittee addition)
Office of Inspector General	33.6	36.4	35.0	-3.8
TOTAL	17,782.4	18,686.0	18,203.3	-2.6

Source: HAC Website, June 4, 2009 and HS&T analysis

*According to the President's FY 2010 Budget Request for NASA, the Administration will update its request for Exploration following the human spaceflight review.

In terms of differences with the President's request, the markup establishes a higher level of funding for Education and a new line item for Construction and environmental compliance. Exploration was recommended at a funding level approximately $670 million less than requested (16.9 percent). In total, the markup is about $483 million (2.6 percent) less than the FY10 request, but 2.4 percent higher than the level enacted for FY09. The Chairman of the Commerce, Justice and Science Subcommittee said in his statement releasing the Subcommittee's FY10 recommendations:

> *"For NASA, the bill provides a total of $18.2 billion, an increase of $421 million over last year's level. Investments have been made in Earth science to further the decadal surveys. The recommendation, however, acknowledges that the Administration has established a blue ribbon panel, led by Dr. Norm Augustine, to review the current vision for human space flight. Funds are provided in the bill to continue investments in human space flight at the same level as provided in fiscal year 2009. Reductions from the budget request should not be viewed as a diminution of my support or that of the Subcommittee in NASA's human space flight activities. Rather, the deferral is taken without prejudice; it is a pause, a time-out, to allow the President to establish his vision for human space exploration and to commit to realistic future funding levels to realize this vision.*
>
> *The Subcommittee looks forward to receiving the findings of Dr. Augustine's panel and the recommendation of the Administration on the way forward. I do believe, however, in order to avoid continuing cost increases and further delays in the initial operating capability of our nation's next generation of human space flight architecture to follow the Shuttle's successful and impressive run, it is imperative that the Administration and Congress provide the necessary resources to meet that policy directive—in the annual President's budget and the annual Congressional budget process. When President Kennedy said we would put a man on the moon, the Nation followed—in spirit and with the resources to get the job done. We collectively should do no differently today."*

The House Appropriations Committee approved the FY 2010 Commerce, Justice and Science appropriations bill by voice vote with no changes on June 9, 2009. A floor vote is scheduled for June 17, 2009.

Aerospace Safety Advisory Panel

Since it was established in 1968 by Congress, the Aerospace Safety Advisory Panel (ASAP) has been evaluating NASA's safety performance and advising the Agency on ways to improve that performance. The Panel, which is a FACA-chartered advisory body, consists of a maximum of nine members who are appointed by

the NASA Administrator and is comprised of recognized safety, management, and engineering experts from industry, academia, and other government agencies.

The ASAP is a senior advisory committee that reports to the NASA Administrator and Congress. The Panel was established by Congress in the aftermath of the January 1967 Apollo 204 spacecraft fire. The Panel's statutory duties, as prescribed in Section 6 of the *NASA Authorization Act of 1968,* Public Law 90–67, 42 U.S.C. 2477 are as follows:

> *"The Panel shall review safety studies and operations plans that are referred to it and shall make reports thereon, shall advise the Administrator with respect to the hazards of proposed operations and with respect to the adequacy of proposed or existing safety standards, and shall perform such other duties as the Administrator may request."*

The Panel was reauthorized in Section 106, Safety Management, Section 6, of the *National Aeronautics and Space Administration Authorization Act of 2005,* [P.L. 109–155].

The ASAP bases its advice on direct observation of NASA operations and decision-making. The Panel provides a report on an annual basis. In addition to examining NASA's management and culture related to safety, the report also examines NASA's compliance with the recommendations of the *Columbia* Accident Investigation Board (CAIB). The former NASA Administrator, Dr. Michael Griffin, also requested advice from the ASAP on technical authority, workforce and risk management practices.

ASAP 2008 Annual Report

The transmittal letter accompanying the 2008 Annual Report issued on April 15, 2009 stated that *"ASAP members believe that NASA and the new Administration stand at a critical crossroads for the Nation. Consequently, the ASAP decided to provide this brief, to-the-point letter report in lieu of the normal lengthier annual report issued by the Panel."* While indicating that on balance, 2008 was a good year for NASA and that the ASAP is optimistic about the future of the Agency and its mission based on NASA's accomplishments in 2008, the Panel also recognized that *"this is a crucial time for NASA, the new Obama Administration, and the country. Important decisions lie ahead."* Issues the Panel identified in the report as critical were:

- **Proposed extension of the Space Shuttle Program.** The ASAP said in its report: *"To maximize safety, minimize wasted effort, and bolster employee morale, any further debate regarding the future of the Shuttle should be undertaken immediately and completed without further delay. From a safety standpoint, the ASAP strongly endorses the NASA position on not extending Shuttle operations beyond successful execution of the December 2008 manifest, completing the ISS. Continuing to fly the Shuttle not only would increase the risk to crews, but also could jeopardize the future U.S. Exploration program by squeezing available resources (and, in the worst case, support) for the Constellation program."*
- **Acceleration of the Constellation Program.** The ASAP in its report that it *"is not convinced that the Ares I and Orion initial operating capability (IOC) date can be improved appreciably by additional resources."*
- **Use of commercial transportation sources.** The report stated that *"There is no evidence that Commercial Orbital Transportation Services (COTS) vehicles will be completed in time to minimize the gap."*
- **Safety and reliability of Soyuz.** At its 2008 Second Quarterly meeting, the Panel expressed concern about the *"safety issues surrounding the Soyuz capsule and its associated recovery module"* following re-entry difficulties experienced by the Russian spacecraft. Although the ASAP said in its annual report that it continues to be concerned about the safety of the Russian Soyuz vehicle, the report also said that the Panel *"is satisfied that NASA is aware of and addressing the potential limitations involved in relying on Soyuz during the gap between Shuttle retirement and Constellation IOC."*
- **Direction of Exploration.** The Panel suggested *"stability of policy and technical goals as particularly crucial for complex, expensive, safe, long-term programs and for cost-efficient, cost-effective, and safe mission plans and workers."* But the Panel also endorsed the standard management and engineering practice of *"periodically reviewing architecture and program plans (including design assumptions, new developments, changing requirements, emerging technologies, and their impact on decisions). Such reviews are particularly useful*

for programs such as Constellation that extend over many years and are subject to external reassessments of fundamental goals."

- **Safety hardwired into Constellation.** The Panel's report said that *"NASA has an important one-time opportunity to better interweave safety as a consistent and more powerful operating parameter by hardwiring safety into the fabric and procedures of the new flagship exploration program, Constellation. Accordingly, NASA should institutionalize safety programs, systems, processes, and reporting."*
- **Upgrading of NASA facilities and equipment.** The report said that: *"During repeated visits to NASA Centers and Headquarters to hold quarterly and insight meetings, the ASAP has noted that deferred maintenance, modification, and upgrading of basic NASA infrastructure deserve higher priority."*
- **Funding consistent with tasks and schedules.** The ASAP said in its report that it *"cannot overemphasize the high-priority need for Congress and the Administration to understand the impact on NASA of the interrelationship among cost, schedule, and risk (which is ignored only at great risk to safety)."*
- **Suitability of agency management approaches.** The Panel made observations on the governance structure, noting positive evolution of the *"new strategic management and governance model at Headquarters and at the NASA Centers"* and a *"new management emphasis on institutional requirements for safety, engineering, facilities, and personnel in the planning process."* However, the Panel expressed concern about the substance, application, and standardization of Human-Rating Requirements (HRR) across the Agency. The report said that *"The new HRR standards move from validating compliance with mandatory failure tolerance requirements to an approach of designing to acceptable risk, but without any apparent clear and visible criteria for estimating "how safe is safe enough" for various mission categories."*
- **Workforce Development and Sustainment.** The Panel said that it supports *"continued attention to workforce planning, development, and sustainment to ensure that technically qualified personnel are available for NASA and its contractors so that these people can identify, manage, and control the complex safety risks of NASA programs."*
- **NASA culture that values the experience of safety and mission assurance. While stating it was impressed with recent developments in NASA's safety culture evolution over the years, the Panel encouraged NASA to perform** *"periodic internal and external measurements based on meaningful metrics."*
- **Technical Standards Program focused on safety and risks.** The Panel stated that *"More robust technical performance standards are necessary to fill the void created by cancellation in the 1990s of numerous military standards and specifications."* Relative to the promulgation of lessons learned, the panel stated that *"NASA should improve its documentation and distribution system to capture and share lessons learned with all NASA Centers, mission directorates at NASA Headquarters, and, when appropriate, the private sector."*
- **CAIB Recommendations.** As mandated by the *NASA Authorization Act of 2005,* the ASAP is responsible for evaluating and reporting annually on NASA compliance with CAIB return-to-flight and continue-to-fly recommendations. The Panel said in its report that it *"is pleased with NASA's overall response"* and acknowledged that the Panel *"knows that the remaining three CAIB recommendations cannot be completely eliminated without major redesign. The Panel thus recommends that NASA use its formal risk acceptance process to make a decision on how to close out the remaining actions."*
- **Astronaut Health.** The Panel said that it had *"made a commitment to monitor the NASA Astronaut Health Care Systems Review and is satisfied with NASA's progress in responding to associated report recommendations."* The Panel noted that since its June 2007 report, NASA had undertaken several actions such as incorporating psychological evaluations as part of the future astronaut selection process.

In addition to its annual report, the Panel also submits Minutes with recommendations resulting from its quarterly meetings. For example, the Panel recommended, following its fourth quarter of 2008 meeting, that *"NASA obtain greater validation that the new Human-Rating Requirements Standard meets the safety re-*

quirements of a broad range of future human space flight programs by scheduling an external review by an independent "gray-beard" assessment panel."

NASA Advisory Council

NASA has had a long tradition of turning to knowledgeable experts for advice and guidance on major program and policy issues facing the agency. This tradition originated with NASA's predecessor organization, the National Advisory Committee for Aeronautics (NACA). With the creation of NASA in 1958, the NACA was abolished, but the tradition of turning to non-government sources for independent judgment and guidance survived. NASA established the NASA Advisory Council (NAC) to assist it with planning for its new and continuing responsibilities in aeronautics, space technology, space science and applications, and human space flight.

Today, the NAC, comprised of senior-level individuals from the private sector (e.g., academia, business, and retired government personnel), meets regularly to offer the NASA Administrator broad perspectives on agency program issues that the Administrator might not otherwise receive. The NAC consists of six committees, each chaired and populated exclusively by Council members. The six committees are:

- Aeronautics Committee
- Audit and Finance Committee
- Exploration Committee
- Human Capital Committee
- Science Committee
- Space Operations Committee

The NAC is composed of members appointed by the NASA Administrator; these members serve at the pleasure of the Administrator. The Council consists of approximately 25 to 35 members, renewable at the discretion of the NASA Administrator. Additionally, the National Academies' Chairs of the Aeronautics and Space Engineering Board and the Space Studies Board sit on the Council as ex-officio members.

The Council is considered "internal" in that it is chartered by NASA, its members are chosen by the Agency, and it provides advice and counsel directly to the NASA Administrator. The Council operates under the *Federal Advisory Committee Act* (FACA) which allows access to government decision-making processes, among other objectives. FACA sets requirements for government-established groups that provide advice to the government and that include non-government employees.

Recent NAC Recommendations and Concerns

The NASA Advisory Council (NAC) meets on a quarterly basis and submits recommendations to the NASA Administrator shortly thereafter. The Council also conducts fact-finding meetings at different NASA facilities. Following its April 16, 2009 meeting, the Council made eight recommendations to NASA that the Council believed would be of assistance to NASA as the Agency continues its implementation of its space exploration mission. The recommendations were:

- **Infusing new talent and knowledge into the NASA workforce.** The Council said that *"continued leadership in space science and exploration requires the constant infusion of new ideas and state-of-the-art knowledge provided by a vibrant and creative workforce. Therefore, NASA is encouraged to pursue avenues that will facilitate new hiring, particularly at the entry-level."*
- **Assessing how NASA TV could be more effective and what is required to accomplish that goal.** The Council stated that *"The outcome of this study should include recommendations for the level and type of resources required to most effectively engage the public and disseminate NASA content."*
- **Teaching and applying lessons learned to NASA's Human Space Flight employees.** The Council said that *"To effectively transfer hard-won "lessons learned" to its human space flight work force, NASA is encouraged to institute recurring training for the workforce using a curriculum based on existing Safety and Mission Assurance materials. The training program should include lessons learned from the Apollo, Skylab, Mir, Shuttle, and ISS accidents, incidents, and close calls."*
- **Documenting and Teaching of Human Space Flight Lessons Learned.** The Council recommended that *"A portion of the NASA training program should focus on lessons learned from the human space flight missions in order to retain historical knowledge, as many older employees will be retiring. NASA*

should document specific major operational lessons learned from human space flight programs. These lessons learned should be written/presented in a format to facilitate ease of training for the next generation of space workers."

- **Conducting a cost-benefit study of possible active methods for orbital debris removal.** The Council encouraged NASA *"to conduct an in-house study of the current and projected orbital debris situation in order to evaluate the costs and benefits of developing a form of debris removal technology. The study should compare the costs of operating in the ever-expanding debris population with those of developing a selective debris removal method, and how those compare with long-term savings from actively reducing the threat of future collisions."*
- **Forming an Exoplanet Exploration Program Analysis Group under the NAC's Astrophysics Subcommittee.** NASA was encouraged to form such a group to conduct analyses at the request of the NAC's Science Committee, the NAC's Astrophysics Subcommittee, and NASA's Science Mission Directorate.
- **Developing a process for identifying non-science requirements and funding for Earth observations.** The Council encouraged NASA *"to work with OSTP and other agencies at the highest levels to define responsibilities and secure funding for Earth observations beyond those recommended by the NRC Decadal Survey to advance Earth System Science."*
- **Conducting an independent study of space communications—requirements, capabilities, and architecture.** The Council encouraged NASA *"to contract for an independent study of space communications needs for science, exploration, and space operations. The report resulting from this study should include findings and recommendations that will assist NASA in planning a communications architecture that will enable the successful conduct of missions planned or conceivable through 2030. This study should result in recommendations that will assist NASA in development of more detailed, quantifiable requirements."*

Prior year recommendations from the NAC dealt with diverse issues, ranging from NASA's need to convene a workshop to provide external community input to the Agency's formulation of the system-level program on Environmentally Responsible Aviation (recently unveiled as part of the FY 2010 budget request) to communicating lessons learned on large mission cost drivers to decadal survey committees. On that last recommendation, the Council was particularly concerned that *"in the last round of NRC decadal surveys, some high priority mission(s) ranked on the basis of an initial cost estimate turned out to be two to four times as expensive to develop. This leads to questions of whether those same rankings would have been assigned had more realistic cost estimates been available, and whether some different mix of missions might have been recommended to achieve the optimal science return within available funding constraints."* The Council concluded that *"the NRC decadal survey committees need to understand how early choices in mission concept design lead to cost growth so they can structure their recommendations to be more robust over time."*

The National Academies

The National Academy of Sciences (NAS) is a private, not-for-profit society of elected scholars in the areas of scientific and engineering research. The Academy is committed to science and technology research and its application to society. The NAS was chartered by Congress in 1861 to *"advise the Federal Government on scientific and technical matters."*

In 1964, the National Academy of Engineering (NAE), a body of renown engineers who are elected to be members, was established under the charter of the NAS, and shares the work with the NAS in advising the Federal Government. In addition, the NAS, in 1970, established the Institute of Medicine (IOM), which is a body of elected, distinguished experts in medicine, health and health policy, to advise the government and *"upon its own initiative, to identify issues of medical care, research, and education."* In 1916, the NAS organized the National Research Council (NRC), *"to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the Federal Government." ". . . the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities."* The NAS, NAE, IOM, and NRC are collectively referred to as The National Academies. A pri-

mary function of the National Academies is to convene *"committees of experts in all areas of scientific and technological endeavor. These experts serve pro bono to address critical national issues and to give advice to the Federal Government and the public."*

The NRC is organized into thematic discipline areas. Within the Division on Engineering and Physical Sciences, the Space Studies Board (SSB) and the Aeronautics and Space Engineering Board (ASEB) oversee ad-hoc committees of experts that prepare reports and provide other information on research, technical and policy areas related to space and aeronautics, and provide advice to the Federal Government in these areas. The Federal Government funds approximately 85 percent of the work of the NRC through individual contracts and grants, according to the National Academies. Individuals representing the SSB and ASEB will testify at the hearing.

Space Studies Board

The Space Studies Board (SSB) was established in 1958 and consists of members from academia, private industry, and not-for-profit organizations with expertise in space science, policy, engineering, and other related fields. The Board *"oversees advisory studies and program assessments, facilitates international research coordination, and promotes communications on space science and science policy between the research community, the Federal Government, and the interested public."* Among its consensus-based studies are the SSB-led "decadal surveys" which provide recommendations, with extensive input from the interested community, on priority missions and research activities to be pursued in the areas of planetary science, solar and space physics, and Earth science and other research objectives. The SSB is also the U.S. national committee to the Committee on Space Research of the International Council of Science, a multi-disciplinary scientific entity that promotes the international exchange of scientific results, information, and discussion on scientific research in space.

The Board is currently undertaking the following activities:

- A decadal survey on biological and physical sciences in space, in cooperation with the Aeronautics and Space Engineering Board;
- A planetary science decadal survey;
- NASA's suborbital research capabilities;
- Astro2010 astronomy and astrophysics decadal survey, in cooperation with the Board on Physics and Astronomy;
- A review of near-Earth object surveys and hazard mitigation strategies, in cooperation with the Aeronautics and Space Engineering Board;
- Development of a workshop report on future international space cooperation and competition in a globalizing world;
- A study of the role and scope of mission-enabling activities in NASA's space and Earth science missions; and
- A study on the rationale and goals of the U.S. civil space program, in cooperation with the Aeronautics and Space Engineering Board.

Recently published SSB reports include:

- *An Assessment of Planetary Protection Requirements for Mars Sample Return Missions*

  NASA requested that the NRC review the findings of an earlier report on planetary protection for a Mars Sample Return mission and to update the recommendations in light of scientific understanding of Mars and advances in relevant technologies.

- *A Performance Assessment of NASA's Heliophysics Program*

  The 2005 *NASA Authorization Act* directed NASA to arrange for the National Academies to review the performance of each of the NASA Science Mission Directorate divisions every five years. This Assessment of NASA's Heliophysics Program reviewed the extent to which NASA's heliophysics division aligned with previous NRC advice, especially the decadal survey report, *The Sun to the Earth—and Beyond: A Decadal Research Strategy in Solar and Space Physics.*

  The report noted that *"Unfortunately, very little of the recommended NASA program priorities from the decadal survey's Integrated Research Strategy will be realized during the period (2004–2013) covered by the survey. Mission cost growth, reordering of survey mission priorities, and unrealized budget as-*

sumptions have delayed or deferred nearly all of the NASA spacecraft missions recommended in the survey. As a result, the status of the Integrated Research Strategy going forward is in jeopardy, and the loss of synergistic capabilities in space will constitute a serious impediment to future progress."

- *Severe Space Weather Events: Understanding Societal and Economic Impacts Workshop Report*

  The report summarized a public workshop held in May 2008 that included presentations and discussions on the *"Nation's current and future ability to manage the effects of space weather events and their societal and economic impacts."*

- *Launching Science: Science Opportunities Provided by NASA's Constellation System*

  The report was requested by NASA. The executive summary notes: *"The committee was impressed with the scientific potential of the many proposals that it evaluated. However, the committee notes that the Constellation System has been justified by NASA and selected in order to enable human exploration beyond low-Earth orbit—not to enable science missions. Virtually all of the science mission concepts that could take advantage of Constellation's unique capabilities are likely to be prohibitively expensive."*

- *Ensuring the Climate Record from the NPOESS and GOES–R Spacecraft: Elements of a Strategy to Recover Measurement Capabilities Lost in Program Restructuring*

  The study was requested by NASA and NOAA to *"prioritize capabilities, especially those related to climate research, that were lost or placed at risk following recent changes to NPOESS and the GOES–R series of polar and geostationary environmental monitoring satellites."*

- *United States Civil Space Policy: Summary of a Workshop*

  The workshop participants considered the goals, purposes and priorities of U.S. civil space including *"key changes and developments since 2003; how space exploration fits in a broader national and international context; sustainability factors, including affordability, public interest, and political will; definitions, metrics, and decision criteria for program portfolio mix and balance; roles of government in Earth observations from space; and requirements and gaps in capabilities and infrastructure."*

- *Opening New Frontiers in Space: Choices for the Next New Frontiers Announcement of Opportunity*

  NASA requested that the NRC conduct a study *"to provide criteria and guiding principles for determining the list of candidate missions"* for the next competition for a New Frontiers mission. The New Frontiers Program to compete principal-investigator-led science missions to explore the solar system with a cost cap of $750 million, according to the report.

- *Space Science and the International Traffic in Arms Regulations: Summary of a Workshop*

  NASA requested that the NRC *"organize a workshop on the implications of ITAR for space science. The purpose of the workshop was to reopen a discussion among State Department regulators and policy-makers, academic researchers and faculty, ITAR officials, NASA officials, and other interested parties to explore concerns about ITAR's effects on space science activities."*

  The NRC summarized the workshop presentations and discussions in a report. The workshop summary noted that *"Over the long-term . . . many believe that a clean-slate approach is needed to fix the fundamental disconnect between ITAR as it is being applied to space science research and the needs of the U.S. space science community as it endeavors to maintain world leadership. The United States has many space-related policy priorities in addition to national security, including space leadership, university excellence, and international partnerships. As emphasized at the workshop, all these national goals need to be considered jointly in the development of a system for controlling the export of space-related hardware and technology that is effective at protecting national security, but that does not inadvertently harm the other policy priorities."*

Aeronautics and Space Engineering Board

Established in 1967, the Aeronautics and Space Engineering Board (ASEB) is comprised of individuals from academia, private industry, and not-for-profit organi-

zations with expertise in aeronautics, aviation, space systems and engineering, and policy. The ASEB *"oversees ad hoc committees that recommend priorities and procedures for achieving aerospace engineering objectives, and offers a way to bring engineering and other related expertise to bear on aerospace issues of national importance."*

The ASEB is currently undertaking the following activities:

- A decadal survey on biological and physical sciences in space, in cooperation with the Space Studies Board;
- A review of Near-Earth Object Surveys and Hazard Mitigation Strategies, in cooperation with the Space Studies Board;
- A study on the rationale and goals of the U.S. civil space program, in cooperation with the Space Studies Board;
- An independent assessment of NASA's National Aviation Operations Monitoring Service (NAOMS) Project; and
- A review of the NASA Institute for Advanced Concepts.

Recently published ASEB reports include:

- *Radioisotope Power Systems: An Imperative for Maintaining U.S. Leadership in Space Exploration*

  The study was conducted in response to House Report 110–240 of the Commerce, Justice, Science and Related Agencies Appropriations Bill, 2008 and assessed NASA's program in radioisotope power systems technology and its ability to meet NASA's near-term and future mission needs and plans.

  According to the report, "Re-establishing domestic production of ^{238}*Pu will be expensive (the cost will likely exceed $150 million). Previous proposals to make this investment have not been enacted, and cost seems to be the major impediment. However, regardless of why these proposals have been rejected, the day of reckoning has arrived. NASA is already making mission-limiting decisions based on the short supply of* ^{238}*Pu."*

- *A Constrained Space Exploration Technology Program: A Review of NASA's Exploration Technology Development Program*

  In response to Congressional direction in the report of the Science, State, Justice, and Commerce fiscal year 2007 appropriations, NASA arranged for an NRC assessment of NASA's Exploration Technology Development Program (ETDP) *"to determine how well the program is aligned with the stated objectives of the Vision for Space Exploration (VSE), identify gaps, and assess the quality of the research."* Although the bill did not become law, NASA proceeded with the request for the study.

  As noted in the executive summary, "A fundamental concern . . . is that the ETDP is currently focused on the short-term challenges of the VSE and is addressing the near-term technologies needed to meet these challenges. Although it is clear that much of this focus results from the constraints on the program, the committee is concerned that the short-term approach characteristic of the current ETDP will have long-term consequences and result in compromised long-term decisions. Extensibility to longer lunar missions and to human exploration of Mars is at risk in the current research portfolio."

- *NASA Aeronautics Research: An Assessment*

  NASA requested the study in response to the *NASA Authorization Act of 2005,* which directed that NASA arrange for an NRC assessment of the NASA aeronautics research portfolio in the context of the recommendations of the NRC Decadal Survey of Civil Aeronautics, NASA's aeronautics research requirements, and the ability of the Nation's research workforce and facilities to address the priority research challenges and requirements for civil aeronautics.

- *Managing Space Radiation Risk in the New Era of Space Exploration*

  NASA requested that the NRC *"evaluate the radiation shielding requirements for lunar missions and to recommend a strategic plan for developing the radiation mitigation capabilities needed to enable the planned lunar mission architecture."*

  As noted in the executive summary of the report, *"The committee finds that the lack of knowledge about the biological effects of and responses to space radiation is the single most important factor limiting the prediction of radiation risk associated with human space exploration."*

- *Assessing the Research and Development Plan for the Next Generation Air Transportation System: A Workshop*

  Upon request by the Federal Aviation Administration's Joint Planning and Development Office (JPDO), the National Academies held a workshop *"to gather observations on the research and development aspects of the baseline Integrated Work Plan for the Next Generation Air Transportation System (NextGen) being prepared by JPDO . . .."*

- *Wake Turbulence: An Obstacle to Increased Air Traffic Capacity*

  The study was conducted pursuant to direction in the *NASA Authorization Act of 2005* [P.L. 109–155] for NASA to enter into an arrangement with the NRC to assess the issue of wake vortex hazard, which has the potential to affect air traffic capacity.

  The authoring committee of the report found *"that the wake vortex problem does present a real impediment to increased traffic capacity, something reflected in most of the documentation that has been drafted to date by the JPDO [Joint Planning and Development Office] . . .. However, although the need to address wake vortex issues is clearly acknowledged, the research required to provide the required solutions is not yet underway."*

Aerospace Industries Association

The Aerospace Industries Association (AIA), founded in 1919 as the Aeronautical Chamber of Commerce, represents about 300 aerospace manufacturing companies and suppliers across all segments of the industry, including commercial aviation and avionics, manned and unmanned defense systems, space technologies, and satellite communications, and the 657,000 skilled workers who develop and manufacture aerospace and aviation systems.

Over the last year, AIA has provided witness testimony on such topics and issues as NextGen air transportation initiative, export controls, NASA and NOAA programs, and STEM education and the aerospace workforce to various House and Senate committees.

In January 2009, the AIA prepared a report, *"The Role of Space in Addressing America's National Priorities"* to provide the new administration and Congress with information on *"the major issues facing our aerospace industry."* The report recommended the development of a national space strategy *"that links national policy with needs, programs and resources"* and that coordinates space across national security, civil and commercial domains.

In addition, the report provided the following recommendations pertaining to civil and commercial space:

- *"Our space capabilities should be coordinated, at the highest level, as a singular enterprise."*
- *"The Administration should provide and support a national budget that reflects both robust and stable funding across space functions to prevent disruptions to the planned life cycle of critical, multi-year space programs."*

Workforce and the Economy

- *"The U.S. Government should work to create opportunities for our current workforce, and make science and education a national priority to ensure a strong future workforce."*
- *"The Administration and Congress should work to create a more favorable business environment for the U.S. aerospace industry."*

Space Exploration

- *"Both the U.S. Space Exploration Policy and the Constellation Program should be treated as national priorities and given the funding and support needed to keep development on its current schedule and to minimize the impending gap in U.S. human space flight."*
- *"The International Space Station should be fully utilized as a national laboratory."*
- *"The NASA science program should receive the funding necessary to provide a wide suite of robotic missions and other research."*

Earth Observation

- *"The U.S. Government should immediately address existing and growing gaps in climate measurements and weather satellite coverage."*
- *"The Administration should establish, fund and implement a U.S. Earth Observation architecture as a national priority."*

National Security Space (as it relates to civil and commercial areas)

- *"Space protection and space situational awareness programs should become a funded national priority."*
- *"The U.S. Government should undergo a careful review of critical space technologies to evaluate which technologies should be controlled under the State Department ITAR process and which are truly commercial and could be controlled under the Commerce Department process. This review must be followed with meaningful and careful legislation that would ensure the right technologies are controlled the right way."*

Astronomy and Astrophysics Advisory Committee

The *National Science Foundation Authorization Act of 2002* [P.L. 107–368] as amended, directed the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the Department of Energy (DOE) to establish the Astronomy and Astrophysics Advisory Committee (AAAC) to

> *"assess, and make recommendations regarding, the coordination of astronomy and astrophysics programs of the Foundation and the National Aeronautics and Space Administration and the Department of Energy"* and to
>
> *"assess, and make recommendations regarding, the status of the activities of the Foundation and the National Aeronautics and Space Administration, and the Department of Energy as they relate to the recommendations contained in the National Research Council's 2000 report, entitled* "Astronomy and Astrophysics in the New Millennium" *and the recommendations contained in subsequent National Research Council reports of a similar nature."*

The AAAC is directed to submit a report every year to the NSF, NASA, and DOE and to relevant Congressional committees. According to its March 15, 2009 report, the AAAC found that interagency cooperation among DOE, NASA, and NSF is strong at the scientist-to-scientist level, the programmatic level, and among small and large projects and facilities. The Committee also found that many of the high-priority projects recommended in the 2000 National Academies Decadal Survey for astronomy and astrophysics have not been implemented.

The Committee made the following recommendations in its March 15, 2009 report:

- *"In the interest of astronomical research, agencies should be encouraged to continue coordinating activities where the science or technology demands it, and furthermore, to map out more clearly the scientific and technological complementarities that might be the basis for future missions/projects. We emphasize coordination, which may, but not necessarily, take the form of joint projects. We emphasize coordination, which may, but not necessarily, take the form of joint projects. Taking advantage of unique skill sets amongst agencies and throughout the world, coordinated access to northern and southern hemispheres of the sky, ground and space access—all important aspects of a vigorous science program."*
- *"Robust cost estimates, including full life cycle costs and external analyses of the budgets, as well as strategic planning for large facilities are a necessity, and should be an integral part of any prioritization and implementation process."*
- *"Assessment of the cooperation within projects involving federal plus international and private partners is now needed, in addition to that of inter-agency projects. Some of these projects have started since the time the AAAC was chartered."*

Attachment 1

Attachment 1

NASA's FY 2010 Budget Request

Budget Authority ($M)	FY 2008	FY 2009	Recovery Act	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Science	**4,733.2**	**4,503.0**	**400.0**	**4,477.2**	**4,747.4**	**4,890.9**	**5,069.0**	**5,185.4**
Earth Science	1,237.4	1,379.6	325.0	1,405.0	1,500.0	1,550.0	1,600.0	1,650.0
Planetary Science	1,312.6	1,325.6		1,346.2	1,500.6	1,577.7	1,600.0	1,633.2
Astrophysics	1,395.6	1,206.2	75.0	1,120.9	1,074.1	1,042.7	1,126.3	1,139.6
Heliophysics	787.6	591.6		605.0	672.6	720.5	742.7	762.6
Aeronautics	**511.4**	**500.0**	**150.0**	**507.0**	**514.0**	**521.0**	**529.0**	**536.0**
Exploration	**3,299.4**	**3,505.5**	**400.0**	**3963.1***	**6076.6***	**6028.5***	**5966.5***	**6195.3***
Constellation Systems	2,675.9	3,033.1	400.0	3,505.4	5,543.3	5,472.0	5,407.6	5,602.6
Advanced Capabilities	623.5	472.3		457.7	533.3	556.5	558.9	592.7
Space Operations	**5,427.2**	**5,764.7**	**0.0**	**6,175.6**	**3,663.8**	**3,485.3**	**3,318.6**	**3,154.8**
Space Shuttle	3,295.4	2,981.7		3,157.1	382.8	67.8	0.0	0.0
International Space Station	1,685.5	2,060.2		2,267.0	2,548.2	2,651.6	2,568.9	2,405.9
Space and Flight Support (SFS)	446.2	722.8		751.5	732.7	745.9	749.7	748.9
Education	**146.8**	**169.2**	**0.0**	**126.1**	**123.8**	**123.8**	**123.8**	**125.5**
Cross-Agency Support	**3,251.4**	**3,306.4**	**50.0**	**3,400.6**	**3,468.4**	**3,525.7**	**3,561.4**	**3,621.4**
Center Management and Operations	2,011.7	2,024.0		2,084.0	2,119.2	2,142.5	2,166.1	2,189.9
Agency Management and Operations	834.1	921.2		961.2	956.9	964.5	972.3	981.5
Institutional Investments	325.5	293.7	50.0	355.4	392.3	418.7	423.0	450.0
Congressionally Directed Items	80.0	67.5		0.0	0.0	0.0	0.0	0.0
Inspector General	**32.6**	**33.6**	**2.0**	**36.4**	**37.0**	**37.8**	**38.7**	**39.6**
NASA FY 2010	**17,401.9**	**17,782.4**	**1,002.0**	**18,686.0**	**18,631.0**	**18,613.0**	**18,607.0**	**18,858.0**
Year to Year Change		2.2%		5.1%	-0.3%	-0.1%	0.0%	1.3%

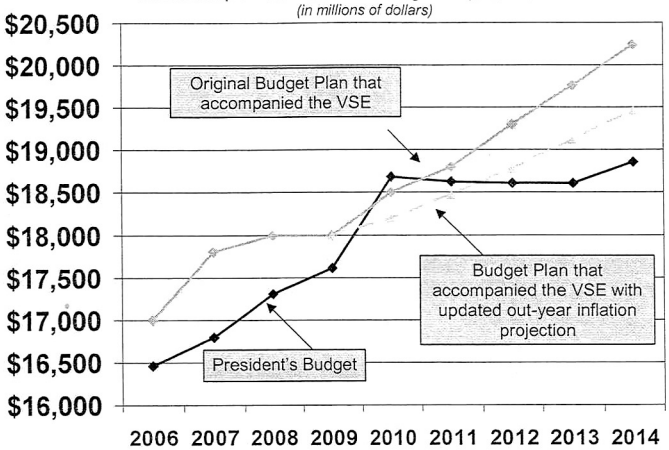
*Following the human spaceflight review, the Administration will provide an updated request for Exploration activities reflecting the review's results.

Attachment 2

Attachment 2

Comparison of Budget Plan that accompanied the VSE (Vision for Space Exploration) in 2004 with actual/planned President's Budget Requests for NASA

(in millions of dollars)



Chairwoman GIFFORDS. Good morning. This hearing has now come to order.

I would like to welcome our witnesses here this morning. All of you have prepared very interesting testimony which is going to be important to the Subcommittee Members, and we look forward to hearing from you.

Because of time constraints, we are going to dispense with our opening statements so that we can hear from you gentlemen. We think that we are going to have votes probably around 10:30, and we would like to get in your formal testimony before we go to questions.

I would just like to do some quick introductions. We have Mr. John Marshall who is testifying as the member of the Aerospace Safety Advisory Panel or the ASAP. We have Dr. Kenneth Ford, the Chairman of the NASA Advisory Council. We have Mr. Robert Hanisee who is the Chairman of the NASA Audit and Finance Committee. Dr. Raymond Colladay, the Chairman of the Aeronautics and Space Engineering Board, and Dr. Berrien Moore who is testifying as a member of the Space Studies Board of the National Academies. And finally, we have Mr. Stevens who is Vice President of Space Systems at the Aerospace Industries Association.

These are an incredible set of witnesses, very important for the Congress as we are truly at a crossroads, our country, in terms of NASA's future, and we are looking forward to hearing from you.

I would like to turn it over to Mr. Olson for just a couple of minutes. I am sorry, Mr. Hall.

[The prepared statement of Chairwoman Giffords follows:]

PREPARED STATEMENT OF CHAIRWOMAN GABRIELLE GIFFORDS

Good morning. I'd like to welcome our witnesses to this morning's hearing. You all have prepared very informative testimony, and I look forward to hearing from you. This is an important hearing for the Subcommittee.

I think that the Aerospace Safety Advisory Panel—the ASAP—which is represented at today's hearing, summed up the situation quite succinctly in its April 15th letter to Speaker Pelosi transmitting its annual report, namely: *". . . NASA and the new Administration stand at a critical crossroads for the Nation."*

I agree with the ASAP. NASA is at a critical crossroads, and decisions made by Congress and the White House this year will have an impact on NASA for years to come—for better or worse—and we need to ensure that they are for the better.

We are going to be making a number of those key decisions as we develop our NASA reauthorization bill later this year. I want those decisions to be as informed as possible. Last month, we got NASA's perspective on its FY 2010 budget request as well as on other issues facing the Agency when Acting Administrator Scolese testified before the Science and Technology Committee.

Today we are continuing our oversight by hearing from the advisory bodies who monitor the NASA's activities and programs, as well as from one of the key organizations representing the aerospace industry.

I welcome your testimony because we need to know, from your unique perspectives, what's going well at NASA, what's not going so well, and what obstacles may lie ahead for the Agency if appropriate corrective actions are not taken. We invited the ASAP to testify because it was established by Congress more than four decades ago to help ensure that NASA's programs and activities are carried out safely—and safety is a paramount concern of this subcommittee. We also wanted to hear from the NASA Advisory Council because it is NASA's main advisory body, whose purview extends over all of the programmatic and institutional issues facing NASA. Among its areas of focus have been NASA's financial management practices, which is why we have also asked the Chair of the NAC's Audit and Finance Committee to testify today.

Good financial management practices are going to be a key factor in ensuring that NASA is a responsible steward of the taxpayers' dollars, and this subcommittee needs to know how NASA is doing in that regard.

The National Academies' Space Studies Board and Aeronautics and Space Engineering Board have long been important sources of advice and analysis for both the Executive Branch and Congress on issues related to NASA's R&D initiatives in science and engineering.

Finally, I wanted to ensure that industry's perspective was also presented at today's hearing, and I can think of no better representative than the Aerospace Industries Association. You thus are a diverse group of witnesses, but you and the organizations that you represent share a common thread of competence and commitment. I hope that each of you will let your colleagues know how much we value their efforts.

We recognize that the members of these advisory bodies have many competing demands on their time, so their willingness to serve is deeply appreciated by all of us on the Subcommittee. And I want to make it a regular practice of this subcommittee to hear from the advisory bodies represented before us today. We need your insights to enable us to carry out our legislative and oversight responsibilities as effectively as possible. With that, I again want to welcome each of you to this morning's hearings, and I look forward to your testimony.

Mr. HALL. That is all right. I would rather be Mr. Olson. He is about 40 years younger than I am.

Well, I thank you, and I will be brief because I know time is important. And I think it should be normal that we listen to them before they have to listen to us, but that is not the way it works here. But we are going to get to do that today, and you can thank this Chairwoman for that, a great panel. And if there is ever a time when NASA and the Space Station and everybody involved needs advice, we need an advisory group like this. Work hard, advise Norm every chance you get on what he winds up with the final paper.

But I will yield back my time. Thank you.

Chairwoman GIFFORDS. As our witnesses know, you will each have five minutes for your spoken testimony. Your written testimony will be included into the record for the hearing, and when you have completed your spoken testimony, we will begin questions. Each Member will have five minutes to question the panel, and we are going to begin with Mr. Hall. Mr. Marshall, I am sorry. You are on my brain.

Mr. HALL. I am Hall.

Chairwoman GIFFORDS. I know, and I love you.

Mr. HALL. Excuse me. She can only say that when her husband, he is an astronaut, she can only say that when he is orbiting.

STATEMENT OF MR. JOHN C. MARSHALL, MEMBER, AEROSPACE SAFETY ADVISORY PANEL (ASAP)

Mr. MARSHALL. Chairwoman Giffords and other distinguished Members of the Subcommittee on Space and Aeronautics, good morning. Thank you for inviting the ASAP to testify before your subcommittee today.

Unfortunately our panel Chair, Vice Admiral Joe Dyer, was unable to participate in this morning's meeting, and he asked me and my colleague, Ken Ford, to represent the ASAP in his place.

Today, you asked us to comment on six specific areas, and so let me go right to those. The first was to identify top priorities in upcoming multi-year NASA authorizations. Without question from the ASAP's perspective, the top priority for this agency is the need to have and maintain a stable and sufficient budget that allows

NASA to safely execute an integrated space program. Safety can be an unintended victim of reduced spending if we are not careful. That should not be allowed to happen to this agency.

Next, an irrevocable decision regarding extending the Space Shuttle Program needs to be made quickly. If the decision is made to extend the Shuttle, then that decision must be accompanied with necessary resources. Without additional budget allocation, all the responsible parties must realize that such an action will seriously constrain available resources for the development of any follow-on program and will only shift and may actually expand the gap in America's flight capabilities. This clearly will expose NASA to the risk of another Shuttle loss and may jeopardize the future of the U.S. Space Exploration Program.

The next priority is to ensure that cost, schedule and the required performances are properly in balance with each other. The ASAP feels strongly that the imbalance of any of these key elements will lead to substantial increase in risk.

You next asked us to identify critical issues facing NASA. We believe that there must be a reaffirmation or redefinition of a set course for the exploration mission. Hopefully, the Augustine Blue Ribbon Panel will do much of this. Even without a change, it is the ASAP conclusion that the recent budget cut of over $500 million makes the current schedule for the Exploration Program unexecutable.

Third, you asked us to discuss NASA's compliance with *Columbia* Accident Investigation Board (CAIB) recommendations. As you know, when the Return to Flight Task Group completed its work in 2005, it had determined that NASA had met the intent of all but three recommendations. The ASAP is pleased with NASA's overall response to the CAIB recommendation yet believes the risk associated with the remaining issues cannot be completely eliminated without major redesign of the Shuttle. Accordingly, the ASAP recommends that NASA use its formal risk acceptance process to make a decision on how to close out the remaining actions.

The CAIB also recommended recertification of the Shuttle if it is to fly beyond 2010. The ASAP concurs with the need for recertification if a significant extension of the current program is directed. This said, NASA has not yet developed an action plan to accomplish this.

Next, you asked us to discuss NASA's incorporation of safety and risk mitigation in its design of a new crewed transportation system. The ASAP has reviewed Orion and Ares developments thus far, and we agree that the issues that have been identified to date are properly being addressed, issues that have come up like vibration and potential tower strikes have been or are being thoroughly investigated.

NASA's role in the Commercial Orbital Transportation Services (COTS) program thus far has been to not directly levy NASA-restricting requirements. While we endorse and support investing in the COTS program, we believe at this juncture that NASA needs to take a more aggressive role articulating human rating requirements for the COTS program since many new commercial vehicles are already under development. To do so at a later date may pres-

sure NASA into accepting a system for expediency that is below its normal standard for safety.

You also asked us to discuss NASA's progress in instilling safety into the agency. The ASAP believes that NASA has continued to improve its awareness and development of a positive safety culture. However, we also believe that more attention is required in the following areas: implement a more robust incident investigation process, develop a standardized way to proactively measure the safety culture at each center, and improve the current technical standards program to better capture and apply hard-won lessons learned and best practices.

Finally, you asked us to discuss other matters that merit attention. We the ASAP believe that the Administration, Congress, and NASA all need to be transparent with the public on risk communication, that losses may occur in space exploration, and the risk of this should be mutually shouldered. The national message on the space program needs to be that we are going to do it but that launching humans into space can never be considered a completely safe endeavor.

I would be happy to answer any questions should you like at a later time.

[The prepared statement of Mr. Marshall follows:]

PREPARED STATEMENT OF JOHN C. MARSHALL

Chairwoman Giffords and other distinguished Members of the Subcommittee on Space and Aeronautics, good morning. Thank you for inviting the Aerospace Safety Advisory Panel (ASAP) to testify before your subcommittee today.

Unfortunately, our panel's Chairman, Vice Admiral Joe Dyer (USN), Ret., is unable to participate in this morning's meeting, and he asked me and my colleague, Mr. John Frost, to represent the ASAP in his place, so I am fortunate to have Mr. Frost in attendance with me this morning. I should state up front that while our panel has several members that have an extensive background with NASA, including Major General Charlie Bolden, President Obama's nominee to be the next NASA administrator; Mr. Jim Bagian, a former mission specialist on two Space Shuttle flights; Ms. Joyce McDevitt, a former system safety engineer for NASA; and Mr. Randy Stone, the former Deputy Director of the Johnson Space Center; neither Mr. Frost nor I bring the hands-on technical expertise of having been either in space or directing daily space activities. Nevertheless, Mr. Frost and I together have over 90 years of experience in aviation, engineering, and safety. Mr. Frost was the Chief of Safety for the Army's Aviation and Missile Command, and I was an Air Force fighter pilot and then the Chief of Safety for Delta Air Lines. With Mr. Frost's valued assistance, I have prepared to talk about issues addressed collectively by the ASAP, and will be pleased to answer your questions.

As you know, the Panel's statutory duties are prescribed in Section 6 of the *NASA Authorization Act of 1968.* Included within this Act is the need for the ASAP to "review safety studies and operations plans that are referred to it and . . . to make reports thereon, . . . advise the Administrator with respect to the hazards of proposed operations and with respect to the adequacy of proposed or existing safety standards, and . . . to perform such other duties as the Administrator may request."

Additionally, the ASAP is required by the *NASA Authorization Act of 2005* to keep the House Committee on Science and Senate Committee on Commerce, Science and Transportation fully informed of its activities.

Since it was established in 1968, the ASAP actively has been fulfilling its charter by evaluating NASA's safety performance and advising the Agency on ways to improve that performance. The ASAP bases its advice on direct observation of NASA operations and decision-making. In the aftermath of the Shuttle *Columbia* accident, Congress required that the ASAP submit an Annual Report to the NASA Administrator and to Congress. This Annual Report was to summarize our major findings concerning the safety performance of NASA. It also is to examine NASA's compliance with the recommendations of the *Columbia* Accident Investigation Board (CAIB), as well as NASA's management and culture related to safety.

Consistent with our charter, on April 15, 2009, we issued our 2008 Annual Report. Today, I would like to formally submit that report to you and your committee for the record. In addition, Admiral Dyer earlier briefed this committee's senior staff, regarding our observations and recommendations. Not surprisingly then, my responses today to your questions identified in the letter of invitation to testify before this subcommittee will be consistent with our report. You asked us to comment on six specific areas:

1. Identify top priorities and issues to consider in upcoming multi-year NASA authorization legislation.

A. Without question, from the ASAP's perspective, the top priority for this agency is the need to have and to maintain a stable and sufficient budget that allows NASA to safely execute an integrated space program that follows the Administration's and Congress' national space objectives. Safety always is an unintended victim of reduced spending and any resultant stretch-out of major programs if we are not careful. That should not be allowed to happen for this agency!

B. Next, an immediate and irrevocable decision regarding extending the Space Shuttle Program or not (as noted in our annual report, the ASAP does not support extending the Shuttle from a safety standpoint) needs to be made quickly. If the decision is made to extend the Shuttle, then that decision must be accompanied with necessary resources. Without additional budget allocation, all the responsible parties must realize that such an action will seriously constrain available resources for development of any follow-on program, and will only shift, and may actually extend, the gap of developing a future vehicle. This clearly will further expose NASA to the risk of another Shuttle loss and may jeopardize the future U.S. exploration program.

C. The next priority is to ensure that cost, schedule, and required performance are properly in balance with each other. The ASAP feels strongly that the imbalance of any of these key elements will lead to a substantial increase in risk. For example, if NASA's performance is held constant in terms of objectives that must be met, and cost is constrained by budgetary authority, then the schedule must extend. If schedule is constrained more than is required to meet more timely milestones, then risk to the mission and crew can only increase—perhaps beyond control with fatal results.

D. Finally, support for the Agency by expeditious confirmation of those selected to lead NASA is critical. Expeditious confirmation will lead to greater stability within NASA and decrease safety risks throughout the Agency.

2. Identify critical issues facing NASA, the corresponding decisions that are required, and the Agency's ability to address these issues within the context of the budgetary outlook described in its FY 2010 request.

A. As noted, a critical issue facing NASA is resolution of the issue of continuing to fly or to retire the Shuttle after completion of the Space Station. If the Shuttle is continued beyond the flights currently planned, the Agency must be given the resources to restart the Shuttle program. Modification and redesign work that was deferred due to the decision to retire the Shuttle must be funded and completed. Again, this restart must be properly funded and staffed with the knowledge that it will now cost more to do this work. The ASAP believes that in the absence of this additional effort, the Shuttle must be retired.

B. Next, there must be a reaffirmation or redefinition of a set course for the Exploration Mission Directorate. This means confirming or developing goals, developing realistic time tables, developing plans consistent with budget realities, and developing the necessary systems to achieve the objectives. Hopefully, the Augustine Blue-Ribbon Panel will do this. This said, the ASAP believes that if Constellation is not the optimum answer, then any other new design has to be substantially superior to justify starting over. If a restart is indeed necessary, no amount of resources will recover the approximately four years of effort that have been expended. It further is the ASAP's conclusion that the current budget cut of approximately $500 million dollars make Constellation (or any other program) unexecutable to meet the current schedule for exploration. There is no such thing in this program as a "pause." Contracts are canceled, teams are dismissed, test windows missed, and industrial capability is shut down. Denying the program funding in 2010 means at best a year to two year interruption . . . and will be the same for any other program.

C. Deferred maintenance, modification, and upgrading of the basic NASA infrastructure, which is more than 40-years-old, deserve a higher priority. Aging facilities are in need of timely repair and upgrades, and a prompt and thorough assessment of NASA's fixed wing aircraft fleet and aircraft support facilities should be funded.

D. The role of robotics in support of human exploration in the NASA of the next decade requires clarification. While optimization of this mix must come from NASA, the long range missions assigned to NASA should not preclude use of robotics when appropriate to minimize human risk and optimize exploration efficiency. This committee should ask NASA for a written strategy and plan, with defined parameters, for when humans are necessary and when they are not.

E. Full funding of the NASA Safety Center is important and necessary so that this new organization properly can begin to serve as the Agency's focal point for developing and integrating safety excellence further into the culture of the Agency.

3. Discuss NASA's compliance with the Columbia Accident Investigation Board's (CAIB) recommendation on "Return to Flight" and "Continue to Fly."

A. As you know, 15 of the 29 CAIB recommendations were designated "Return to Flight." When the Return-to-Flight Task Group completed its work in 2005 (when the monitoring function was transferred to the ASAP), it had determined that NASA had met the intent of all but three issues:

- Dealing with External Tank Debris Shedding,
- Orbiter hardening,
- and, Thermal Protection System Inspection and Repair.

B. The ASAP has received periodic updates regarding the status and progress on the remaining three areas. We are pleased with NASA's overall response and believe the residual risk associated with the remaining recommendations cannot be completely eliminated without a major redesign of the current Shuttle. Accordingly, the ASAP recommended that NASA use its formal risk acceptance process to make a decision on how to close out the remaining actions.

C. As recommended by the CAIB, recertification of the Space Shuttle materials, components, subsystem, and system levels would be required to "continue to fly" the Shuttle beyond 2010. The ASAP concurs with that recommendation. This said, NASA has not yet undertaken the development of an action plan to accomplish this.

D. The ASAP will continue to monitor the remaining three CAIB issues, as required by its mandate, and is prepared to immediately engage the Agency if required.

4. NASA's incorporation of safety and risk mitigation in its design of new crewed transportation systems:

A. Safety and risk mitigation for any future crewed systems needs to continue to receive the highest level of support. We have reviewed Orion's development, and we have agreed that issues that have been identified to date are properly being addressed with developmental mitigation plans and tests. Issues that have come up like the "vibration" and the potential tower strike have been or are being thoroughly investigated and subjected to substantial multi-disciplinary technical reviews using both government and industry teams, as well as outside expertise.

B. The Constellation program offers a one-time opportunity for safety to be better hard-wired into overall NASA processes. Experience has shown that one of the best ways for a large organization to advance the state-of-the-art of its processes is to institutionalize the procedures developed by a major new program that is highly motivated and staffed with the best and brightest. Constellation provides such an opportunity to lead NASA safety culture into the future. NASA must capitalize on this opportunity to improve long-term safety improvements.

C. NASA's role in the COTS programs for manned transport systems thus far has been to not directly levy NASA-restricting requirements. This has been a subject of some debate between NASA and the panel for several meetings. While we endorse and support investing in a COTS program, we believe at

this juncture that NASA needs to take a more aggressive role articulating human rating requirements for the COTS Program since most programs are well underway. To do otherwise may, at a later time, pressure NASA into accepting a system for expediency that is below its normal standard for safety. This said, we applaud NASA providing the COTS manufacturers with all their lessons learned. As a separate, but like issue, the ASAP has reviewed the Constellation/Orion systems engineering process and how they are managing the human rating process. We have not found any lack of attention or faulty process thus far.

D. The ASAP has concerns about recently revised NASA Human Rating requirements standard with regard to substance, application, and standardization NASA-wide. Direct linkage to current technical standards and engineering directives is missing; NASA must integrate its technical requirements to its new human rating requirements before new Constellation systems are finalized.

5. Discuss NASA's progress in instilling and maintaining safety in the Agency's culture, standards, and processes:

The ASAP believes that NASA has continued to improve its awareness and development of a positive safety culture. Areas where improvements have been made include:

A. Implementation of a new governance model and acceptance and implementation throughout the agency of independent engineering and safety Technical Authority policies.

B. Establishment of an agency-wide Safety Center.

C. Initial funding to support the use of a senior-level leadership team within the Safety Center.

D. Endorsement that experience in the Safety and Mission Assurance (S&MA) career field will be a strong requirement for promotion into senior management positions.

E. Safe Shuttle and International Space Station operations have been demonstrated successfully since the *Columbia* accident. The recent Hubble rescue mission was a masterpiece for safety. As a side note, NASA deserves significant recognition for continuously operating manned the Space Station safely in orbit for nine years without a major incident—quite an accomplishment.

F. Development of an astronaut medical health Technical Authority that establishes checks and balances among program and institutional requirements.

G. Positive changes in workforce attitude towards safety, continued awareness of safety and risk programs, and continued management effort to create and nurture open dialogue and discourse on technical differences.

However, there can be more attention put forth into the following:

A. Improve contractor safety management and communications at all centers.

B. Implement a more robust incident investigation process that not only identifies the root causes but then distributes the lesson-learned information in a timely manner to those who need to know.

C. Develop a standardized set of hard and soft, leading and lagging safety metrics that are reviewed and analyzed by each center's management team on a monthly basis; such an analysis would then enable them to focus attention on the areas that need more critical intervention and will stimulate comparisons between centers.

D. Develop a standardized way to proactively measure the safety culture at each center; then continue to foster the required leadership behaviors to engender the openness. Transparency and trust are needed to ensure that safety issues are solved at the lowest possible level in the organization.

E. Improve the current technical standards program to better capture and apply hard-won lessons learned and best practices.

6. Discuss any other matters that merit attention:

A. The Administration, Congress, and NASA all need to be transparent with the public on risk communication—that losses may occur in space exploration and the risk of this should be mutually shouldered; the national message on the space program needs to be that we're going to do it, but that launching humans into space with today's technology can never be consid-

ered a completely safe endeavor as judged by normal standards; this message is complicated further by the tendency of the media to communicate issues with an exaggerated "spin."

B. NASA is addressing the potential limitations involved in relying on Soyuz during the gap between the Shuttle retirement and Constellation initial operating capability (IOC). In the meantime, a good, open working relationship with the Russians at a high level is necessary for any period of dependence on Soyuz.

C. NASA currently has a good plan for managing the workforce transition from the Space Shuttle to the Constellation program. The ASAP concerns involve retention of key technical, engineering, and management leaders and include the need for Office of Personnel Management (OPM) to grant NASA authority to reemploy retired NASA civil service annuitants without financial penalty from the retirement compensation offset, particularly at Marshall Space Flight Center where a large influx of Department of Defense Base Realignment and Closure positions provides unfair competition.

Once again, I thank you for the opportunity to offer the ASAP's view on these issues and would be happy to respond to any questions you or other Members of the Subcommittee may have.

BIOGRAPHY FOR JOHN C. MARSHALL

- Independent Aviation Consultant
- Former Delta Airlines, Vice President Corporate Safety and Compliance

Mr. John C. Marshall is an independent aviation consultant who formerly was Vice President of Corporate Safety and Compliance for Delta Air Lines. Mr. Marshall had responsibility for six departments at Delta, including Flight Safety, Industrial Safety, Environmental Services, Emergency Planning and Operations, Safety Analysis and Quality Assurance, and Security. Inherent in these organizations are FAA, DOT, DOD, OSHA, EPA, TSA, and DHS compliance-driven programs for accident prevention, accident investigations, accident response, and a wide range of security programs. He also has collateral responsibilities for integrating safety, compliance, and security programs for Delta's wholly-owned subsidiaries including Comair, Atlantic Southeast Airlines, Delta Global Services, and Delta Technologies, into Delta's mainstream programs. Under his leadership, Delta routinely was recognized for industry-leading programs focused on reducing aircraft mishaps, employee injuries, and aircraft ground damages, while enhancing environmental compliance programs and fostering the highest standards of security for world-wide commercial airline operations.

Mr. Marshall recently served as the Industry Co-Chair of the Commercial Aviation Safety Team (CAST). CAST is a joint industry-government program to develop and implement an integrated, data-driven strategy to reduce the U.S. commercial aviation fatal accident rate by 80 percent by 2007. Participants include aircraft and engine manufactures, passenger and cargo airlines, labor unions, Flight Safety Foundation, Air Transport and Regional Airline Associations, NASA, DOD, and the FAA. Mr. Marshall is also the past Chairman of the Air Transport Association of America's Safety Council and the Society of Automotive Engineer's Aerospace Symposium. He currently serves on boards for the National Defense Transportation Association's Military Subcommittee, Safe America (a nation-wide non-profit organization focusing on safety awareness), the Flight Safety Foundation, and the Nature Conservancy's International Leadership Council.

Mr. Marshall gained world-wide aviation experience through his 26-year aviation career with the U.S. Air Force. His Air Force assignments included duties as a fighter pilot, special assistant to the Air Force Vice Chief of Staff, fighter squadron commander, base commander, and fighter wing commander. During his career, he primarily flew F–4s, F–15s, A–10s, and F–16s, but has experience in a variety of other aircraft as well. Mr. Marshall later served as the Inspector General of the Pacific Air Forces and then became the Director of Operations of the Pacific Air Forces. While in the Pacific, he oversaw the safe and efficient operations of over 400 combat aircraft, including developing plans and policies used for executing his command's annual flying program. In his last assignment, he served as the United State's Director of Security Assistance for the Middle East where he was responsible for all sales, marketing, training, and logistic support between the United States and eleven countries in the Middle East, Africa, and Southwest Asia during and immediately after the Gulf War.

Mr. Marshall received his Bachelor's degree in civil engineering from the Air Force Academy in Colorado. He also is a graduate from the National War College, holds a Master of Arts degree in personnel management from Central Michigan University, and a Master of Science degree in civil engineering (environmental) from the University of Hawaii.

Chairwoman GIFFORDS. Thank you, Mr. Marshall. Dr. Ford, please.

STATEMENT OF DR. KENNETH M. FORD, CHAIRMAN, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION ADVISORY COUNCIL (NAC)

Dr. FORD. Chairwoman Giffords and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the top priorities and challenges facing NASA. I have submitted my complete testimony for the record, but today I would like to identify and discuss what I believe to be three of the highest priorities for your consideration during this potentially pivotal moment in our nation's space program.

Choices and decisions must be made that will determine what we can and cannot accomplish in space for the next 40 years. The three priorities include developing a capable and flexible space transportation architecture, the need to reestablish a robust technology R&D program, and the need for stability of purpose, policy and funding. In the few minutes I have, I will address each of these in turn.

It is very likely that the space transportation system now under development will serve the nation for the next 30 to 50 years. We need to get it right. This will be the space flight architecture that takes Americans beyond low-Earth orbit back to the Moon to near-Earth objects and onto Mars. The key element in the exploration architecture is the development of the heavy-lift launch vehicle. I urge Congress to accelerate and prioritize development of this capability as it is the lynchpin to everything we will do in human space flight beyond low-Earth orbit.

Accelerated development of the heavy-lift launch vehicle would also help with retaining a skilled workforce, both in production and in the processing that takes place at Kennedy Space Center. The plan has been to apply the workforce coming off Shuttle to development of the Shuttle-derived heavy lift Ares-5.

Assuming that the International Space Station is to be extended beyond 2015, serious thought must be given to the means of support for both cargo and crew. The current space transportation architecture is intended to provide government-furnished crew access to the International Space Station. As NASA has clearly stated from the outset, if commercial crew access materializes, NASA will utilize that service. Although commercial cargo transport may be available sooner, it seems unlikely that commercial crew transport to the International Space Station will be available before 2015 or 2016 and even then only with a substantial infusion of additional government funding. That said, unless the Constellation Program is funded at or above the 2010 budget request, it seems equally unlikely that Ares-1 will be available before 2016 or perhaps even early 2017. In fact, the latest House mark-up would likely further increase the gap in U.S. Government-provided access to space to the point where Ares-1 support of the International Space Station

may become irrelevant unless operation of the space station is extended well into the future.

NASA has long enjoyed a reputation as a technology innovator whose stressing applications in space and aeronautics have led to an incredible range of broadly useful technologies. Several years ago the decision was made to divert a large fraction of the Agency's technology investment into the Constellation Program with the goal of maintaining an early initial operational capability. Unfortunately, technology research programs are easily stopped and terribly hard to restart. In a time of constrained budgets, it will take strong and effective leadership at the agency and by Congress to reestablish NASA as a technology leader. A large part of the public's strong support for NASA derives from the perception that NASA is a driver of innovation and technology.

Space exploration is an inherently challenging and rewarding endeavor. Stability in planning requirements, budgets, and programmatic execution are essential for successful mission accomplishment. The current U.S. space policy is the best one we have had for a very long time. It meets existing commitments and then puts NASA on a new path in an orderly, disciplined manner. The policy strategy was strongly supported by both the 2005 and 2008 *NASA Authorization Acts* in both a Republican and a Democratic Congress. It is NASA's job to implement that policy. In my view, the most important factor in NASA's future success will be stability in purpose, strategy, requirements and funding. If our nation's leadership cannot provide that stability, NASA's efforts to implement the Nation's space policy will cost more and accomplish less.

In most days, there is very little in the thousands of items filling the 24-hour news cycle that will be regarded as important and noteworthy in 500 years. However, the accomplishments of this agency of the United States Government are among the few human activities that will be regarded as having mattered and been important and will be looked upon with admiration centuries hence. They will marvel at the courage, curiosity and audacity of a people who put the first human footprint on a planet other than their own, who sent robotic ambassadors deep into the solar system, not to conquer or for financial gain, but just to know. They will wonder if they could measure up to such people. I look back at the Apollo era and wonder the same thing and hope that our generation will also be included as worthy of their admiration. We will not have to wait 500 years to know the answer. We are now at a critical juncture in the future of U.S. human space flight.

I would be happy to respond to any questions you or other Members of the Committee might have.

[The prepared statement of Dr. Ford follows:]

PREPARED STATEMENT OF KENNETH M. FORD

Chairwoman Giffords and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the top priorities and challenges facing NASA, the corresponding decisions that are required, and the Agency's ability to address these issues within the context of the budgetary outlook described by its 2010 request.

The NASA Advisory Council (NAC) was also asked to discuss the corrective actions NASA has taken to implement a solid financial management foundation and merit an improved audit opinion. The NAC, through our Audit and Finance Committee under the leadership of Mr. Robert Hanisee, has worked closely with NASA

on these areas. Mr. Hanisee will provide you with a comprehensive account of the progress that has been made and the issues remaining. We are pleased with the tremendous improvements that NASA has made in its financial management.

Next month we will celebrate the 40th anniversary of the first human footprint on a world other than our own. This is a time for our nation to both look back with pride in our accomplishments and to look forward with great expectations for the next 40 years in space. It is also time to re-commit ourselves to taking those next steps.

I will identify what I believe to be a few of the highest priorities for your consideration during this potentially pivotal moment in our nation's space program. Choices and decisions will be made that will determine what we can and cannot accomplish in space for the next 40 years.

Flying the Shuttle Safely

NASA has developed a prudent and technically rigorous approach to Shuttle operations. Human space flight remains one of the hardest things humans do. When the inevitable technical problems have arisen, NASA has consistently demonstrated the commitment to take whatever time necessary to resolve the problem before proceeding in a safe, deliberate manner. The challenge will be to maintain this level of vigilance through the remaining seven flights of the Space Shuttle program. Commendably, Congress and the Administration have laid the foundation by directing NASA to focus on completing the remaining Space Shuttle flights, rather than forcing the Agency to finish the Shuttle flights by an arbitrary deadline. The Congress and Administration must be prepared to act on this direction by providing additional funding in the case that the flights need to be delayed. This strategy eliminates the perception of schedule pressure that may cloud safety and technical decision-making. It is equally important that NASA retains the critical workforce skills and facilities that are needed to ensure the safe completion of the Shuttle program. Congress and the Agency can help provide a sense that the work that the Agency is doing in space is recognized as being necessary and important to the country. This is accomplished by providing stable funding and an unwavering vision for the future. Such an approach will significantly help with workforce retention. In summary, while NASA's current plans to complete the final seven flights of the Space Shuttle program by the end of 2010 are indeed ambitious, the Agency has the mechanisms in place to safely complete the Shuttle missions. NASA must, however, remain vigilant, taking one mission at a time, doing it right, and doing it safely.

Develop a Capable and Flexible Space Transportation Architecture

In the aftermath of the loss of Space Shuttle *Columbia,* Admiral Hal Gehman, Chairman of the *Columbia* Accident Investigation Board, released a remarkable report that pointed to the fact that NASA had operated for more than three decades in the absence of a guiding vision for human space flight as a root cause of the *Columbia* accident. In response, a thoughtful and logical civil space policy was put forth. After extensive and healthy debate, a Republican Congress approved this policy as the guiding strategy for NASA, and three years later a Democratic Congress did likewise. Both presidential candidates in 2008 issued specific statements supporting a strong human space program, and President Obama's first budget request calls for lunar return by 2020. Thus, in the last five years two presidents and two Congresses, each of opposite parties, have affirmed the United States Vision for Space Exploration.

It is NASA's responsibility to implement the vision within the resources provided by Congress. It is very likely that the space transportation system now under development will need to serve the nation for the next 30–50 years. We need to get it right. This will be the basic space flight architecture that takes Americans beyond low-Earth orbit (LEO), back to the Moon, to Near-Earth Objects and on to Mars.

The key element in the exploration architecture is the development of a heavy lift launch vehicle. I urge Congress to accelerate and prioritize development of this capability as it is the key to everything we will do in human space flight beyond LEO. Accelerated development of a heavy lift launch vehicle can also help with retaining a skilled workforce both in production and the processing that takes place at Kennedy Space Center. The plan has been to apply the work force coming off Shuttle to development of the Shuttle-derived heavy lift Ares-V. With the budget that would have funded early lunar work now eliminated, the work force transition is further at risk. For the Ares-V concept, the five-segment solid rocket booster and J2X upper stage engine are already in development. The first five-segment booster test firing is planned for August of this year. The J2X engine passed its critical design review

last fall. Although many technical challenges lie ahead, substantial progress *has* been made.

As noted above, a heavy lift capability is mandatory for journeys beyond LEO. The Ares-V and Orion are sized for missions to Mars. The crew of six and Ares-V lift capabilities were originally derived from Mars mission studies. These capabilities encompass all other human missions that are feasible at this time, including the Moon, asteroids, LaGrange points, and near-Earth objects.

Building a heavy lift launch capability and doing so on an aggressive schedule is the right thing because not only does it provide the ability to go beyond LEO, but it also enables a step-wise and evolutionary building block to progressively longer and more demanding science and exploration missions to explore the Moon, Mars, and other locations. Making this choice and stepping up to it now is a wise investment in our future that will undoubtedly yield untold benefits.

Assuming that the International Space Station (ISS) is to be extended beyond 2015, serious thought must be given to the means of support for both cargo and crew. The current Space Transportation Architecture is intended to provide Government-furnished crew access to the ISS. As NASA has clearly stated from the outset, if commercial crew access materializes, NASA will utilize that service. Although commercial cargo transport may be available sooner, it seems unlikely that commercial crew transport to ISS will be available before 2015 or 2016—and even then only with a substantial infusion of additional Government funding. That said, unless the Constellation Program is funded at or above the 2010 budget request, it seems equally unlikely that Ares-I will be available before 2016 or perhaps even early 2017. Continued schedule slippage could leave the ISS without a U.S.-provided crew transportation capability for an extended period of time. If Ares-I/Orion significantly slips schedule, the argument for their necessity weakens dramatically. In fact, the latest House markup would likely further increase the gap in U.S. Government-provided access to space to the point where Ares-I support of ISS may become irrelevant unless ISS operation is extended well beyond 2015.

There are, of course, other options for access to ISS. These options will have budget impacts and may not be executable in time to support ISS. The aforementioned options could include increased reliance on international partners (*Soyuz*), more Shuttle flights, a smaller capsule on a human-rated EELV, an Orion capsule on a human-rated heavy lift launch vehicle—or some combination of the above. There are significant challenges and difficulties associated with each of these approaches. We, as a Nation, need to confirm our strategy and then let NASA implement it with adequate and stable resources.

When a program such as Constellation has to re-plan, due to significant budget cuts, it means that schedules are shifted and contracts must be changed and renegotiated to a new baseline, inevitably at higher cost. The schedule delays also impact the ability to retain the highly skilled workforce currently working in support of the Shuttle and ISS systems. As the schedule slips, workers are first impacted in the hardware manufacturing facilities, and then as launch and orbit operations are delayed, workers are impacted in launch processing and operations. These workers have unique skills, and it is important to retain much of this workforce for the new systems. This unstable funding scenario is reminiscent of the instability in the Space Station Freedom yearly budgets in the late 80's and early 90's that resulted in annual re-planning, cost overruns, and delays. Large-scale engineering development programs and the associated contracts cannot be stopped and started without the inefficiency of re-planning, loss of critical skills, additional significant costs, and loss of schedule. I hope that this is a "lesson learned," and that it will not have to be *relearned* at great cost. The current budget environment is jeopardizing the future of U.S. human space flight at a time when NASA has made significant progress toward development of the new Space Transportation Architecture.

On October 16, 2008 the NAC Exploration Committee offered the following formal observation following their careful evaluation of progress on the Ares Launch Vehicle,

> *"Given the quality of NASA's analysis and the project's momentum, it is imperative to maintain stability and continuing progress on execution of the current plan. The Ares project is well underway with an established baseline and provides a solid foundation for the Constellation Program. The current Exploration Program has strong and accelerating international support and participation."*

The NAC Exploration Committee will continue to monitor progress toward development of the Space Transportation Architecture that will serve this nation for decades to come and make recommendations as merited.

Need for a Decision Regarding International Space Station (ISS)

I believe the International Space Station (ISS) to be among the most ambitious engineering projects ever undertaken by humanity. It's larger than a football field, weighs nearly a million pounds, and is gracefully orbiting our planet at 7.7 kilometers per second. Perhaps equally impressive has been the fifteen-nation partnership that designed, built, and operates the ISS.

When it is finished, the ISS will be a laboratory unique in human experience. Already, preliminary results look promising for progress toward development of new vaccines and therapeutic drugs against salmonella and MRSA. But more importantly, it affords an opportunity for humans to learn to live and work in space for long durations. This knowledge will be of great value when we are ready to send humans to the Moon and eventually Mars. The lessons of long-duration space flight are better learned when you are only hours away from the safety of Earth, and not days away when on the Moon, or months away when traveling to Mars.

Currently, there is no consistent direction for ISS utilization past 2015 other than to take no action to preclude its continued operation. A timely decision regarding the future of ISS is needed. Uncertainty of purpose and plan is damaging for science utilization, negotiation with our international partners, and development of a stable commercial cargo market.

Space Station has cost us much in treasure ($50+ billion) and in human life, but now it is nearly finished. It would seem imprudent to have spent the last 25 years building this remarkable facility only to abandon it shortly after completion.

Re-establish a Robust Technology R&D Program at NASA

NASA has long enjoyed a reputation as a technology innovator whose stressing applications in space and aeronautics have led to an incredible range of broadly useful technologies. Several years ago, the decision was made to divert a large fraction of the Agency's technology investment into the Constellation Program with the goal of maintaining an early initial operational capability. As a result, NASA no longer enjoys the benefits of a strong technology program and is very limited in its ability to seek new ideas both internal and external.

Unfortunately, technology research programs are easily stopped and terribly hard to restart. In a time of constrained budgets, it will take strong and effective leadership at the Agency and by Congress to reestablish NASA as a technology leader. The moral of this story is that viable and productive research programs require stability.

A robust and useful technology program at NASA would be dedicated to stimulating innovation and developing new capabilities not tied to existing mission requirements. There are many negative consequences associated with the loss of a technology research program, but one of them is that missions, such as NASA's science missions, must carry all the technology risk in the mission itself. Additionally, in the human space flight side of the house, the lack of a robust technology program has naturally driven program managers toward relatively conservative and often low-tech designs.

A large part of the public's strong support for NASA derives from the once accurate perception that NASA is a driver of innovation and technology. The NASA Advisory Council is in the process of examining NASA's current technology programs in terms of quality, scope, and adequacy—and will make a recommendation as appropriate.

On the Need for Stability

Space Exploration is an inherently challenging and rewarding endeavor—it takes courage, calculations, capital, choreography, and consistency. Stability in planning, requirements, budgets, and programmatic execution are essential for successful mission accomplishment.

The current U.S. Space Policy is the best one we have had for a very long time: it meets existing commitments, and then puts NASA on a new path in an orderly, disciplined, manner. The policy strategy was strongly supported by both the 2005 and 2008 *NASA Authorization Acts* in both Republican and Democratic Congresses. It is NASA's job to implement that policy.

In my view, the most important factor in NASA's future success will be stability in purpose, strategy, requirements, and funding. If our nation's leadership cannot provide that stability, NASA's efforts to implement the nation's space policy will cost more and accomplish less.

NAC assessment of NASA responses to NAC recommendations on (a) human capital and (b) science mission cost drivers:

Infusing new talent and knowledge into the NASA workforce

The NAC believes that continued leadership in aeronautics, space science, and exploration requires the constant infusion of new ideas and state-of-the-art technological knowledge provided by a vibrant and creative workforce. As a result of very limited hiring at NASA over the past 15 years, a large proportion of the new hires were those with a higher level of experience and expertise. As a consequence, NASA's current workforce consists primarily of mid-level and senior-level professional scientists and engineers. Therefore, to ensure that NASA has the talent needed to support current and future space and aeronautics missions, the NAC has recommended that NASA focus on hiring "fresh-out" talent, which is defined as individuals who have obtained a degree within the past three years.

NASA has already begun taking steps to address the issue raised by the NAC. NASA has secured support from the Office of Science and Technology Policy (OSTP) to pursue increased hiring specifically for the purpose of enhancing the workforce pipeline. As a result of this support, NASA has made two substantive and strategic hiring commitments to infuse new entry-level talent and knowledge into its workforce. First, NASA has initiated a pilot program designed to target approximately 200 additional hires in FY09 as a near-term infusion of entry-level talent. To implement this program, the Office of Human Capital Management is partnering with the Mission Directorates, the Office of Diversity and Equal Opportunity, and the Office of Education to provide guidance and direction to the Centers on a strategic hiring plan that targets recruitment efforts that are consistent with merit system principles. Second, NASA has committed to using a higher proportion of its annual hiring opportunities created through natural attrition on entry-level hires. The Centers have already been directed to replenish losses with a higher number of entry-level hires.

The tasks we ask NASA to accomplish on behalf of the Nation are some of the hardest things humans do. Thus, while the NAC is pleased with NASA's efforts to balance its workforce, we hope that it will make every effort to recruit the very best talent to the Agency. Our nation's continued leadership in Space and Aeronautics will depend on NASA's ability to hire the "best and the brightest."

Communicating lessons learned on large cost drivers in science missions to inform the next round of decadal surveys

In general, NASA does a good job of estimating prices, as well as managing schedules and costs for small (e.g., Explorer-class) and medium size science missions. In these cases, the science scope and new technology development are relatively modest, and so costs and risks are better understood. In recent years, the problems with under-costing and maintaining schedule have nearly all arisen from flagship class missions. For these large science platforms, the required technology advances have been very significant in order to meet bold new science goals. Thus, it is not surprising for these one-of-a-kind missions that costs or schedules are sometimes exceeded because extrapolation from existing models is an inadequate predictor. This is NASA's dilemma for large science missions and parallels problems experienced by other federal agencies (e.g., NOAA, DOD space missions, and even recent NSF large ground-based projects). Solutions to the cost estimation and cost containment problems for large, unique missions are among NASA's (and all federal agencies) greatest challenges. Maintaining realistic yet ambitious science goals, leading to more incremental new technology requirements, coupled with larger up-front mission reserves are likely to be elements needed for successful large space science missions for the future.

The NAC Science Committee has played an active role in monitoring, reviewing, and suggesting changes regarding the management of costs for science missions. The Committee reviews the status and expenditures of NASA's major science missions (e.g., JWST, JDEM, MSL, MMS) quarterly at each of its meetings. NASA managers present updates on technology, engineering, and science goals for science missions to discipline subcommittees who review, comment, and make recommendations to the NAC Science Committee. The NAC compares previous expectations on design and construction along with expenditures for major missions to the actual progress in each quarter. Technical and budget problems are probed, explanations are sought, and solutions are then reviewed by the NAC who advise the Administrator on emerging mission issues.

Recently, the NAC recommended that NASA compile lessons learned on the costing of science missions. The NAC believes the NRC decadal survey committees need to understand how early choices in mission concept design lead to cost growth so they can structure their recommendations to be more robust over time. Therefore, the NAC recommended that NASA compile lessons learned on pre-phase B cost esti-

mation for large missions, including influence of interactions among the science community, the NRC, NASA Headquarters, and Centers. Additionally, NASA was asked to provide an initial product to the NAC Science Committee at its July 2009 meeting prior to provision to the NRC committees initiating their new round of decadal surveys in the space sciences.

The NRC decadal surveys establish community and stakeholder expectations for science missions to be developed and launched in the coming decade or beyond. Mission concepts are generally ranked in priority order by cost class. In the last round of NRC decadal surveys, some high priority mission(s) ranked on the basis of an initial cost estimate turned out to be two to four times as expensive to develop. This leads to questions of whether those same rankings would have been assigned had more realistic cost estimates been available, and whether some different mix of missions might have been recommended to achieve the optimal science return within available funding constraints. Thus, the current astronomy and astrophysics, and planetary science decadal surveys are contracting for independent cost estimates for proposed new missions.

NASA's response to the NAC recommendation noted that the Congress, in the 2008 *NASA Authorization Act,* had a similar concern and required NASA to arrange for "an independent external assessment to identify the primary causes of cost growth." To comply, NASA contracted with the National Research Council of the National Academies to conduct this study. The study will:

- Review the body of existing studies related to NASA space and Earth science missions and identify their key causes of cost growth and strategies for mitigating cost growth;
- Assess whether those key causes remain applicable in the current environment and identify any new major causes; and
- Evaluate effectiveness of current and planned NASA cost growth mitigation strategies and, as appropriate, recommend new strategies to ensure better cost containment and success of future missions.

NASA intends for this study to achieve the NAC recommendation. NASA's view is that tasking the NRC to do this study should facilitate the use of its results by the decadal survey committees, which are also NRC entities. The results of this study will be timely for the planetary sciences decadal survey but may not be available in time to impact the astronomy and astrophysics survey.

The NRC "lessons learned" study along with the Decadal Surveys must wrestle with the trade-offs between ambitious science goals, new technology requirements, and costs. The NAC will continue to be vigilant in working with NASA to continuously review each flagship science mission and to apply the lessons learned from the upcoming NRC study.

Conclusion

My letter of invitation asked me what were the most important issues and decisions that must be made regarding NASA. You will notice that I did not talk much about the Space Science or Aeronautics Mission Directorates. This is not because they are unimportant: to the contrary, they are very important, but they are each on paths going forward that seem more clear and less full of doubt than the path for human space flight.

In most days, there is very little among the thousands of items filling the 24-hour news cycle that will be regarded as important and noteworthy in 500 years. However, the accomplishments of this Agency of the U.S. Government are among the few human activities that will be looked upon with admiration and, if humans are still capable of the emotion, with awe. They will marvel at the courage, curiosity, and audacity of a people who put the first human foot print on a planet other than their own, who sent their robotic ambassadors deep into the solar system . . . not to conquer . . . or for financial gain . . . but just to know. They will wonder if they could measure up to such people.

I look back at the Apollo era and wonder the same thing . . . and hope that our generation will also be included as worthy of their admiration. We will not have to wait 500 years to know the answer.

I would be happy to respond to any questions you or the other Members of the Subcommittee may have.

BIOGRAPHY FOR KENNETH M. FORD

Kenneth Ford is Founder and CEO of the Institute for Human & Machine Cognition (IHMC)—a not-for-profit research institute located in Pensacola, Florida.

IHMC has grown into one of the Nation's premier research organizations with world-class scientists and engineers investigating a broad range of topics related to building technological systems aimed at amplifying and extending human cognitive and perceptual capacities. Richard Florida has described IHMC as "a new model for interdisciplinary research institutes that strive to be both entrepreneurial and academic, firmly grounded and inspiringly ambitious." IHMC headquarters are in Pensacola and a branch research facility will soon open in Ocala, Florida.

Dr. Ford is the author or co-author of hundreds of scientific papers and six books. Ford's research interests include: artificial intelligence, cognitive science, human-centered computing, and entrepreneurship in government and academia. He received a Ph.D. in Computer Science from Tulane University. He is Emeritus Editor-in-Chief of AAAI/MIT Press and has been involved in the editing of several journals. Dr. Ford is a Fellow of the Association for the Advancement of Artificial Intelligence (AAAI), a member of the American Association for the Advancement of Science, a member of the Association for Computing Machinery (ACM), a member of the IEEE Computer Society, and a member of the National Association of Scholars. Dr. Ford has received many awards and honors including the Doctor Honoris Causas from the University of Bordeaux in 2005 and the 2008 Robert S. Englemore Memorial Award for his work in artificial intelligence (AI).

In January 1997, Dr. Ford was asked by NASA to develop and direct its new Center of Excellence in Information Technology at the Ames Research Center in Silicon Valley. He served as Associate Center Director and Director of NASA's Center of Excellence in Information Technology. In July 1999, Dr. Ford was awarded the NASA Outstanding Leadership Medal. That same year, Dr. Ford returned to private life and to the IHMC.

In October of 2002, President George W. Bush nominated Dr. Ford to serve on the National Science Board and the United States Senate confirmed his nomination in March of 2003. The National Science Board (NSB) is the governing board of the National Science Foundation (NSF) and plays an important role in advising the President and Congress on science policy issues.

In 2004, Ford was the recipient of the Pensacola Area Chamber of Commerce Business Leader of the Year Award for the growth of IHMC. Also, in 2004 Florida Trend Magazine named Dr. Ford one of Florida's four most influential citizens working in academia. In 2005, Dr. Ford was appointed and sworn in as a member of the Air Force Science Advisory Board.

In 2007, he became a member of the NASA Advisory Council and on October 16, 2008, Dr. Ford was named as Chairman of the NASA Advisory Council.

Chairwoman GIFFORDS. Thank you, Dr. Ford. Very moving comments. Thank you. Mr. Hanisee.

STATEMENT OF MR. ROBERT M. HANISEE, CHAIRMAN, AUDIT AND FINANCE COMMITTEE, NASA ADVISORY COUNCIL (NAC)

Mr. HANISEE. Madam Chairman and Members of the Subcommittee, good morning, and thank you for the opportunity to appear today to discuss the NASA Advisory Council's key findings and observations related to NASA's financial management activities. I will also touch briefly on the perception of a proliferation of conflicting earned-value management approaches within the Agency.

The fact that NASA has been plagued with financial problems for several decades is well-documented. In 1990, the General Accountability Office (GAO) placed NASA on its high-risk list, and in 2005, the GAO issued a report in which it listed 45 recommendations aimed at improving NASA's overall management. In a separate report, the Inspector General (IG) noted that the Agency's problems were rooted in historic culture, to wit, NASA Centers operated with a high degree of autonomy; across NASA there were in use 10 different accounting systems with 120 subsystems; a very significant result of this accounting anarchy was a legacy of unreliable historic data; and that headquarters accounting personnel were inadequately trained. In 2000, well before the GAO report, NASA at-

tempted to consolidate these disparate accounting systems into a new, overarching control system, the Integrated Enterprise Management Plan, and two years later installed a commercially available core accounting system. Both of these new control systems brought forth a host of new problems that would take years and multiple software patches to fix.

In 2006, the headquarters Chief Financial Officer's (CFO) office prepared a corrective action plan to address the noted deficiencies and specifically to remediate the four material weaknesses and one reportable condition cited in both the 2003 and 2004 external audit reports. Those deficiencies were financial systems analysis and oversight; property accounting; funds balance with treasury; general controls, and estimating environmental liabilities. Even though the agency's external auditors continued to disclaim an opinion through and including 2008, the continued hard work of the agency's headquarters and center finance staff has yielded results. In 2005, the number of material weaknesses dropped to three, and in 2006 to only two, and the reportable condition for environmental liabilities dropped off the list.

In the 2008 audit report, Ernst & Young stated that, *"Significant progress has been made,"* even though they again issued a disclaimer citing the remaining two material weaknesses, financial systems, and property accounting.

With several software patches to the core accounting system, a more stable, better-trained accounting staff and the cooperative spirit of the centers, we believe that the first of these two material weaknesses is close to earning a passing grade. The intractable problem is property accounting, particularly as it relates to legacy assets, Space Shuttle, and the International Space Station.

The external auditing firm has stated that the agency cannot earn a clean opinion until this accounting data is cleaned up. The IG has opined that the cost to go back and recreate a set of data that would be auditable is too high to justify. Other than running out the clock on Shuttle and Space Station, the only way off the horns of this dilemma would be a change in accounting interpretation from the Financial Accounting Standards Advisory Board permitting the Agency to write off these assets as research and development. If this accounting change comes forth, the door will be open for NASA to merit an improved audit opinion.

Now to concerns about potential proliferation of conflicting EVM management systems within NASA. Under the leadership of the Chief Engineer's Office, the Earned Value Management Working Group was created in partnership with the Constellation Program with the objective of developing an agency-wide Earned Value Management (EVM) system to be offered to all mission and centers for single adoption. The NAC Audit and Finance Committee suggested at the October 2008 NAC meeting that the single solution being developed by the Working Group be adopted agency-wide. Since the Office of Chief Engineer and the Earned Value Management Working Group were already headed in that direction, no formal recommendation was made at that time.

In conclusion, the Audit and Finance Committee would like the Subcommittee to know that when NASA earns an unqualified audit opinion, hopefully within the next two years, that the credit will

belong to the hard-working accounting personnel at headquarters and in the centers. A specific tip of the hat is due to Terry Bowie, Deputy Headquarters CFO, who is largely responsible for the progress that the Agency has achieved. We also have a high degree of confidence in new headquarters CFO, Ron Spoehel. NASA now has a great financial team in place to address the problems in the future.

Thank you, Madam Chairman.

[The prepared statement of Mr. Hanisee follows:]

PREPARED STATEMENT OF ROBERT M. HANISEE

Chairwoman Giffords and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the NASA Advisory Council's key findings and observations related to NASA's financial management activities.

NASA has well documented financial problems that have plagued the Agency for almost all of this decade. Before describing the remediation efforts and progress made over the last three and one-half years, it would be helpful to begin with a brief explanation of the situation that existed in late 2005. As background, the last year in which NASA received an unqualified Audit Opinion was 2002, but even that opinion is suspect because the opinion contained a Material Weakness which, post Sarbanes-Oxley, would preclude a favorable opinion. In 2001 and in every other year this decade, the Agency was given a Disclaimer which is a statement by the Independent Auditor that the Financial Statements are not auditable.

In 1990, the General Accountability Office (GAO) placed NASA on its High Risk List for what it cited as NASA's failure to effectively oversee its contracts, due in part to the Agency's lack of accurate and reliable information on contract spending. The GAO cited four subject areas:

- Past award Contract Administration;
- Financial Management Systems;
- Program and Project Management; and
- Cost Estimating and Analysis

In 2005, the House Science Subcommittee on Space and Aeronautics tasked the GAO to investigate the long-standing financial management challenges that threaten the Agency's ability to manage its programs. In its report to the Subcommittee, GAO cited 45 recommendations aimed at improving NASA's overall management and implementation of the Integrated Enterprise Management Plan (IEMP) and core accounting system, concluding that "ineffective system and processes and inadequately trained financial management personnel hamper the external financial reporting efforts thereby threatening the Agency's ability to manage its programs and produce auditable financial statements."

In October 2005, at the start of Subcommittee hearings, the Inspector General (IG), in its report, noted that the Agency's problems are rooted in historic culture, to wit:

- NASA Centers operated with a high degree of autonomy and mission focus;
- Across NASA, there were in use ten different accounting systems and 120 sub systems, (none of which could communicate with each other) that were consolidated into a new control system, IEMP and a new common accounting module (widely used in the U.S. and Europe) developed by a German Software vendor, SAP;
- A significant part of the recent problems are rooted in unreliable historical data;
- Not all Headquarters OCFO personnel were sufficiently trained, especially on the new core accounting system;
- At the various centers, there were weaknesses and insufficient controls to catch mistakes early in the accounting cycle.

In January 2006, the Office of the CFO prepared a Corrective Action Plan (CAP) to address the deficiencies noted in the GAO and IG reports and specifically to remediate the Material Weaknesses and Reportable Conditions noted in the 2003 and 2004 audit report of the Independent Auditors. This CAP defined NASA goals, objectives, strategies, due dates, and assigned responsibility for remediation. In the audit

reports of 2003 and 2004, there were four Material Weaknesses and one Reportable Condition:

- Financial Systems, Analysis and Oversight;
- Funds Balance with Treasury;
- Property, Plant and Equipment accounting;
- Estimating environmental liabilities;
- General controls.

Other problems/issues raised by the various oversight entities include:

- Control and accounting for NASA-owned aircraft;
- Control of Travel expenses, (disbursements and reimbursements);
- Grant accounting;
- OCFO personnel shortfalls, turnover and morale.

In addition to the control deficiencies noted above, the Administrator added a few, such as:

- Unobligated Balances;
- NASA Shared Service Center.

While the two above-noted issues are not a concern of any of the oversight entities, they are reflective of the overall controls environment within the Agency and, so, are worth reviewing.

The following examines each of these issues in more detail.

Financial Systems, Analysis, and Oversight

This area was cited as a Material Weakness in each of the last seven years. Despite much progress, there continues to be problems with data entry, system configuration, documentation and compliance with the *Federal Financial Management Improvement Act of 1996* (FFMIA). In 2000, NASA implemented a new IEMP and a new core accounting system. The core accounting system, installed in a phased approach from October 2002 to July 2003, proved to be complex and lacking in flexibility, particularly in reversing mistaken entries into the bookkeeping system. A major version update designed to correct some of the original problems was installed in October 2006. This new update created some new problems which were fixed with a patch implemented in February 2007. Most of the problems that have plagued the system have now been cleaned up.

Funds Balance with U.S. Treasury

This area was cited as a Material Weakness in 2003, 2004 and 2005. At 2002 year-end, the Agency was out of balance with Treasury by $1.7 billion. By 2005, this metric had been reduced to $46 million. In 2006, with a non material unreconciled balance of $10.7 million the Material Weakness was removed. In 2007, this balance was further reduced to only $2 million and NASA received a "green rating" from the Treasury.

Property, Plant, and Equipment Accounting

This area was noted as a Material Weakness for each of the past seven years. Furthermore, it is the last and most intractable impediment to the Agency receiving a clean audit opinion. Prior to 1998, government agencies were not required to capitalize capital assets. Thereafter, the accounting rules changed requiring capitalization and subsequent depreciation. Recall the point made earlier about unreliable historical data. This lack of good historic data, particularly for the iconic legacy programs, such as Shuttle and the International Space Station (ISS), has left NASA with property accounts that NASA's external, independent auditor, Ernst & Young (E&Y), says are not auditable; hence, the Material Weakness.

This problem is equally difficult for Agency-controlled assets or contractor-held assets. With the latter, the periodic reports have often been inaccurate, or not sufficiently timely. To address this problem, NASA installed a software control package called Contractor-Held Asset Tracking System (CHATS) in September 2004. A second problem had to do with the property accounting system not tying into the core accounting module. This was remedied in May of 2008 with the installation of the Integrated Asset Management (IAM) tool, a SAP furnished asset management module. These two programs should help the Agency gain control of the issue on the new programs such as Constellation (Ares and Orion) and Commercial Orbital Transportation System (COTS), but it will not solve the legacy asset problem.

The Agency is stuck on the horns of a dilemma. The cost to go back and reproduce accurate data for legacy programs is prohibitively high, such that the IG will not authorize the effort. E&Y has stated that NASA will not be able to obtain a clean opinion until the issue is resolved. Time will fix the problem as the legacy assets will be completely retired and of no significant value; the Space Shuttle is currently scheduled for retirement in 2010 and the International Space Station in 2016. At the end of 2008, these legacy assets were on the books for $14.2 billion, of which ISS accounted for the preponderance, $13.2 billion. However, to wait until 2016 or beyond to secure a clean audit opinion would be a bitter pill, particularly in light of the tremendous progress made by the Agency in dealing with all of the other accounting problems. There is currently an effort underway to resolve this problem. In 2006, NASA had a similar/related problem with accounting for theme satellites (that were well beyond NASA control) that the Agency was able to resolve. It did so by the CFO's office petitioning Federal Accounting Standards Advisory Board (FASAB) to permit the Agency to treat these assets as research and development (R&D) and write them off. The effort was successful. In 2007, the Agency wrote off almost $13 billion, a move that significantly reduced the amount of assets remaining on NASA's books. There is an exposure draft (currently circulating) from FASAB that if implemented would let NASA write off these legacy assets as R&D. If accepted, this would solve the Agency's problem.

Environmental Liabilities

This was a Reportable Condition in 2004 and 2005. The responsibility for estimating Environmental Liabilities cuts across several NASA departments, including primarily accounting and environmental administration. To resolve this Reportable Condition, the Agency adopted a software package used by the U.S. Navy, the Integrated Data Evaluation and Analysis Library (IDEAL) in 2004. At 2008 year-end, NASA had an unfunded environmental liability of $943 million—some of which will take 50 to 100 years to clean up. The individual projects have liabilities ranging from as low as $12 thousand to $168 million. Each year, NASA spends $45 million on environmental clean-up. Although, in recent audits, Environmental Liabilities was dropped as a Reportable Condition, interviews with the lead audit partner of E&Y indicate that it still is a closely watched issue with them. First, they are not comfortable that the IDEAL software produces stable, auditable estimates and they want the software to undergo independent verification and validation. Second, they want the Agency to produce an estimate of environmental liability at the beginning of each new program.

A new issue has recently arisen which is compliance with SFAS–6, an accounting standard that would, beginning in 2010, require all Government agencies to produce an estimate for asbestos remediation at every one of its sites. A disagreement has arisen between E&Y and the NASA Environmental Department over an acceptable methodology to accomplish this. E&Y wants NASA to do a site-by-site survey to establish these estimates. The Environmental Department believes that it can do an Agency-wide estimate using the costs for already completed remediations at several NASA sites. The Agency was recently informed that is has some breathing room on this issue given that FASAB has proposed a two-year delay in the requirement to estimate asbestos related clean-up costs.

Grant Accounting

While not cited as a significant accounting issue in past audit reports, this issue has been noted by E&Y as an issue that is on their radar screen. NASA's Grant Portfolio consists of approximately 8000 active grants with 1000 institutions, aggregating $6.9 billion. The concern expressed by the auditors is that there are a large number of grants that are still open even though the money has been expended. Also, there are numerous grants for which the documentation that the 'deliverable' was actually delivered is missing or inadequate. In addition, there are grants for which money has been authorized with no activity by the grantees. To address these issues, the Agency recently switched from Block Grant accounting to Grant-by-Grant accounting. This switch occurred in 2008 and was implemented by all Centers except Goddard, which is pressing to close out completed grants. Goddard expects to be compliant by 2009 year-end.

Unobligated Balances

Unobligated balances (money in the possession of the Agency that has not yet been invested in a specific program, project, mission or Center) have typically ranged from $1.5 billion to over $2.0 billion. The previous Administrator was concerned that these unobligated funds could be at risk. Accordingly, he challenged the

Agency to get this metric below $1.0 billion at year-end. In April 2008, Ron Spoehel, the new CFO, undertook the development of a Phasing, Planning and Reporting process to enable Agency resource managers to invest appropriated funds more effectively. With the aid of this new tool, year-end unfunded balances dropped from over $2.0 billion in 2007 to $535 million in 2008. In April 2009, the unfunded balance had been reduced to $343 million.

Summary of Current Status

In the 2008 year-end Audit Report, E&Y stated that "significant progress has been made" in resolving accounting problems. That year ended with there still being two Material Weaknesses, but the Funds Balance with Treasury weakness was no longer a deficiency and the reportable condition on estimating Environmental Liabilities had been removed. On every issue discussed above, the Agency has made progress.

No longer mentioned in audit reports are concerns about the control and accounting for the NASA aircraft fleet, control of Travel expenses, and General Controls. Grant Accounting is well on its way to a satisfactory resolution. And, while Unobligated Balances is an issue that does not directly relate to Financial Controls, the success in reducing the Unobligated Balances is noteworthy. This is also true as to the resolution of the problem of under-staffing in the Headquarters accounting. The NASA Shared Services Center (NSSC) is up and running with performance metrics close to or above the goal levels. Unfortunately, NSSC is unlikely to ever achieve the $100 million cost savings that was the original justification for its creation because of persistent low-transaction volumes.

The two remaining Material Weaknesses, Financial Systems, Analysis and Oversight (FSA&O) and Property Accounting may also be on a path to satisfactory resolution. Certainly, removal of the deficiency in FSA&O is within reach, which leaves Property accounting as the long pole in the tent. Even though E&Y has said that NASA will never receive an unqualified Audit Opinion until this issue is resolved, either by recreating an auditable data set, or by running out the clock on the International Space Station we remain optimistic that the aforementioned change in accounting permitting NASA to write off these legacy assets as R&D will be implemented. If that happens, we believe NASA may earn a clean audit opinion, if not this year then by 2010.

Addressing the proliferation of conflicting Earned Value Management (EVM) approaches within the Agency

In 2008, then NAC Chairman, the Honorable Harrison Schmitt asked the NAC Audit and Finance Committee to "review and advise on how to better monitor the cost buildup on new programs as measured against their original budgets and estimated cost to complete." Subsequently, in 2009, Dr. Kenneth Ford, the current NAC Chairman, made cost estimation and containment a focus area for 2009. Pursuant to that request, the A&F committee requested a fact finding session on the Agency's approach to Earned Value Management (EVM).

EVM is a management tool used to track the performance of projects and programs against the plan and captures the key elements of cost, schedule and technical performance. The tool enables management to assess the trade-offs between cost, schedule, and technical performance and to project the likely future performance of those projects and programs. EVM is a sophisticated attempt to compare the value of work accomplished during a given period with the work scheduled for that period. Its benefits far exceed the traditional two-dimensional approach of comparing planned costs to actual costs. NASA policy requires implementation of an EVM System (EVMS) on all contracted work. It is the internal development of an EVMS for the program and project work within NASA with which the Committee concerned itself.

In October 2008, the Committee was given a briefing on NASA's use of EVM by Ms. Dorothy Tiffany from NASA's Office of the Chief Engineer. Ms. Tiffany stated that NASA is committed to implementing an EVM System that 1) complies with its program management policies in NASA Procedural Requirement (NPR) 7120.5D and 2) that for all development efforts, its EVMS would be compliant with ANSI/EIA–748, which is the EVMS certification standard for Government contractors. While the initial thrust was developing a partnership between the Constellation program and the Agency's EVMS Working Group, the objective was to develop an Agency-wide EVMS that was validated by DCMA. When this EVMS is fully developed and validated, NASA's plan is to offer it to all Missions and Centers for single adoption. To gain support for the EVMS, NASA's strategy was to be a bottom-up approach to "sell" an enterprise solution and to build EVM competency through a series of

training courses. Since October 2007, 1600 participants from all NASA Centers have attended 62 tailored EVM, scheduling, and budget courses.

Based on the limited information briefed to the NAC on this topic thus far, the NAC Audit and Finance Committee believes that the Agency's work is on the right track. However, the Committee has some concern that the adoption of the EVM System being developed was not compulsory for all projects, programs, missions and Centers, even though the stated goal of the Agency Working Group was universal adoption. Having noted in our many "fact finding" sessions that there's a cultural tendency within NASA to "go our own way," the Committee suggested in its report to the NAC at the October 2008 meeting that the single solution being developed by the Working Group be adopted Agency-wide. Since the Office of the Chief Engineer and the EVMS Working Group were already heading in that direction, no formal recommendation was made at that time. The NAC will continue to monitor NASA's progress on this topic and provide recommendations, as needed.

BIOGRAPHY FOR ROBERT M. HANISEE

Mr. Hanisee joined TCW in 1990. He has been a member of the Private Client Services Group since 1997 where he served as Chief Investment Officer and was in charge of Asset Allocation. From 1990 to 1996 he was Director of Research; from 1992 to 1998 he was Manager of the $1.2BYN Convertible Securities Group; from 1992 to 1996 he was Portfolio Advisor of Large Cap Equities Investment strategy; from 1992 to 1997 he was Chairman of the Equity Policy Committee; and from 1996 to 1998 Portfolio Manager of the $155MYN Global Telecom Trust where he was responsible for conception, implementation and management.

In January, 2004, Mr. Hanisee retired from his full time duties, but continues on a part time basis. His current TCW duties include membership on the Comprehensive Asset Allocation Committee and he continues to Chair various equity portfolio oversight committees. He continues to serve as a member of the Equity Policy Committee.

Business experience prior to joining TCW: 1980–1990, President and Director of Research, Seidler Amdec Securities, Los Angeles, CA; 1974–1980, Director of Research and Partner, Crowell Weedon & Co., Los Angeles, CA; 1971–1974, Director of Research, Stern Frank Meyer and Fox, Los Angeles, CA; 1968–1971, Senior Analyst and Group Leader, Merrill Lynch, Los Angeles, CA; 1966–1968, Trainee then analyst, JP Morgan Bank, New York, NY; 1959–1962, U.S. Army, Europe.

Other financially related business experience: 1980–1990, *Investment Banking:* Completed over 20 public financings, including IPO's and secondary offerings, both equity and debt. *Venture Capital:* Involved in initial round and follow-on financing of five defense and technology VC startup's. Continued involvement with each through either board membership or financial consulting.

Outside Boards and other business related activities: EDO Corp., New York, NY, NYSE Listed 1991 to 2007 (Edo was acquired by ITT Corp. in Dec., 2007): Chairman, Audit Committee; Member, Corporate Governance and Nominating Committee; Member, Compensation Committee; Chairman of the Board of Directors, 1994–1996. Orbital Sciences, Dullas, VA, NYSE Listed 2002 to present: Chairman, Audit Committee; Member, Corporate Governance and Nominating Committee. Titan Corp, San Diego, CA, NYSE listed. 1998 to 2005. (Titan was acquired by LLL on July 29, 2005): Chairman, Audit Committee. Space Computer Corp. Los Angeles, Privately held. 2004 to present: Member, Audit Committee. Davidson Companies (Privately held Investment Bank, Broker Dealer, headquartered in Montana. Member, Audit and Finance Committee; Member, Corporate Governance Committee; Chairman, Compensation Committee. Wavestream Corp, San Dimas, CA (Investor and board observer) 2003 to 2008. Other business and related activities: Jet Propulsion Laboratories, Pasadena, CA: Member, Commercialization Council 1999 to 2001. Al Mann Institute for Biomedical Engineering: Chairman, Commercialization Committee, 2001 to 2003. NASA Advisory Council, Appointed 2005. Los Angeles Master Chorale: Member, Board of Directors, 2003 to present.

Mr. Hanisee holds a BA in Economics from California State University at Northridge and an MA in Economics from the University of California at Berkeley. He is a Chartered Financial Analyst (CFA) and a member of the Los Angeles Society of Financial Analysts and the CFA Institute. He has taught financial analysis for aspiring CFA candidates. He is a member of the Dean's advisory council, Business and Economics Dept, California State University at Northridge.

Mr. Hanisee is married to Denise Jamin Hanisee and is the father of six adult children.

Chairwoman GIFFORDS. Thank you, Mr. Hanisee. Dr. Colladay.

STATEMENT OF DR. RAYMOND S. COLLADAY, CHAIRMAN, NATIONAL ACADEMIES' AERONAUTICS AND SPACE ENGINEERING BOARD (ASEB)

Dr. COLLADAY. Madam Chairwoman and Members of the Subcommittee, I appreciate the opportunity to appear before you this morning.

Mentioning many aspects of the extraordinary performance of NASA in my formal testimony, I would like to concentrate and focus my remarks here on a concern over the general lack of attention being paid by NASA to technology development as a priority mission area.

Because of budget pressures, NASA has largely backed away from the development of space technology as a mission. Once the decision was made to focus research and technology specifically on major development program needs by moving the resources to "mission areas" it intended to serve, it became near-term oriented as risk reduction backstopping the hardware development. That isn't to say, of course, there isn't good technology coming from space science and exploration driven by known program needs, but that is not the opportunity-driven type of research and technology development that I believe NASA needs to pursue and has pursued in the past, that is, long-term research driven and defined by anticipating what future program managers will need well in front of requirements, and broad in scope, supporting civil space, not just NASA, and commercial space.

NASA has inspired us with bold missions and spectacular accomplishments, and it needs to be investing in technology that continually seeks to transform the state-of-the-art capabilities and enable future missions that some day we know we will want to do if we only know how.

NASA should revitalize advanced space technology development as a priority mission area of the Agency. It should engage the best science and engineering talent in the country wherever it resides, in universities, industry, NASA centers, other government labs, focused on world-class research and innovation and not driven by the need to maintain core competencies at the NASA centers. It should support not only future NASA missions but other government agencies and commercial space. So its customers are very similar to the broad scope of customers that its aeronautics program serves by enabling the broad aerospace community with advanced technology and development.

That brings me briefly to aeronautics where there is extraordinarily good news this year, and the restructured program is pursuing fundamental research, stable, and providing excellent results. I am particularly pleased with the new emphasis on systems research in this year's request. The environmentally responsible aviation program builds on the progress of the base program and begins to address complex systems interactions accompanying the integration of technology to achieve lower fuel consumption, lower emissions, lower noise, improved safety, and greater air traffic system capacity, all extremely important to our country economically and in moving goods and services across the country.

The bottom line I would say my concern is that there aren't sufficient resources not only for technology development in space and

aeronautics, but the Agency has insufficient resources to accomplish what they, and I think the public, expect of them. I have looked—and every time I have looked at the resources against the program that NASA has on the books right now, I am led to the conclusion that they need approximately $22 to $23 billion to accomplish what is before them. And I think that is a—with that amount, it would compete reasonably in discretionary resource expenditures of the country.

I look forward to answering any questions you might have later when we get to that part of the morning.

[The prepared statement of Dr. Colladay follows:]

PREPARED STATEMENT OF RAYMOND S. COLLADAY

Madame Chairwoman and Members of the Subcommittee, I appreciate the opportunity to appear before you today. My name is Ray Colladay and the personal views I express are shaped by my 40 years of experience in aerospace, through positions I have held in government, industry, and academia. I chair the Aeronautics and Space Engineering Board (ASEB) of the National Research Council (NRC) and although I have insights into NASA acquired through that position, my views are my own and do not represent an official position of the NRC.

With your permission, I would like to submit my prepared testimony for the record and summarize my views for you here this morning, leaving sufficient time to answer any questions you may have.

Civil, commercial, and national security space and aviation affects every part of our lives. It inspires, it facilitates a one-world community, it encourages training and education in science and engineering, it protects our future, and addresses the profound questions of our place in the universe—how did we get here and are we alone? NASA has demonstrated its ability to accomplish great things. It has a vision for the future for which there is general consensus in broad terms even as the finer details are debated. There are two fundamental questions that are pertinent to the subject of this hearing in dealing with NASA and its primary role of providing U.S. leadership in space and aeronautics: are the programs and the goals of the Agency the right ones for the nation to be pursuing?—which is to say is the path and the destination right? And are there sufficient resources to effectively implement the program and the vision being pursued? I would like to address both of these questions in my remarks this morning.

There are a number of issues in the human space flight program that need to be untangled like what to do with the ISS beyond 2016; is the Constellation program headed in the right direction and does it have the commitment and support of this administration; is the timing for Shuttle retirement right; and are the replacement vehicles—Ares and Orion—the best approach to move beyond low-Earth orbit? The recently appointed Augustine Human Space Flight Review Committee will address these issues and present options charting a clear way forward.

Until the disposition of the ISS is decided, there is a big hole in mission planning with uncertain out-year budget implications. The issue is not just are we going to keep the station beyond 2016, which seems likely given how much we have spent finally getting it assembled and ready for full occupancy, but more importantly, what are we going to use it for? This is a remarkable facility and a significant accomplishment in engineering design and on-orbit assembly. It is a modern-day example of cooperative program management on an international scale; not a simple feat. As we transition from the assembly phase to utilization, we should take full advantage of its utility for research to expand our knowledge of how to live and work in space. Having said that, however, the vision and destination for human space flight should be outward, beyond low-Earth orbit. The ISS is a way-point in that journey outward and I believe it will prove to be indispensable in learning to take the next steps.

The NASA science program continues to amaze the world with its spectacular achievements. The science community has led the way in providing consensus views on planning and roadmaps for the future through its Decadal Surveys. We borrowed the technique on the Aeronautics and Space Engineering Board for the Decadal Survey of Civil Aeronautics in 2006. Others will address the state of space science and I will limit my remarks to a shared concern about cost growth in ongoing programs and projects that put other projects at risk and crowd out new-start opportunities.

There are a number of reasons for cost growth on projects—from poor initial cost estimates to over-confidence in what can be done with constrained budgets to years of inadequate attention paid to advance space technology development. I would like to specifically address the last point. Because of budget pressures, NASA has turned away from putting a priority on advanced technology development, even though the *Space Act of 1958* and every subsequent amendment calls for NASA to be a leader in R&D. Today the advanced technology base is so deficient it is costing us in lost opportunities to do bold things with more capable systems and is costing us valuable resources in overruns some of which could be avoided with a more robust technology base.

Aeronautics is underfunded, but a broad-based, innovative advanced space technology development program that is organizationally independent of ongoing hardware development programs is nonexistent. The downward trend started soon after aeronautics and space technology, once logically managed together, were split apart. A decision soon followed to focus technology specifically on major development program needs by moving the resources to mission areas it intended to serve. Predictably, once all technology development was placed with the major development efforts it became near-term oriented as a risk reduction effort back-stopping hardware development. The Aeronautics and Space Engineering Board sponsored study on the Exploration Technology Development Program for Constellation done last year expressed concern on just that point of the need for more emphasis on longer-term research. With budget and schedule pressures as demanding as ever, the situation has not improved. Clearly, there is a need for focused, risk-reduction technology that is defined by explicit mission requirements and funded by the mission office, but it does not fill the need for the Agency on a broader level to pursue long-term technology "push" well out in front of requirements and broad in scope supporting civil (not just NASA) and commercial space. An agency that has inspired us with bold missions and spectacular accomplishments needs to be investing in technology that continually seeks to transform state-of-the-art capabilities and enable future missions that some day we may want to do, if we only knew how.

In DARPA, when I was Director, we sought to be disruptive with technology that challenges or disrupts conventional thinking and it is still doing that today. By setting up a healthy tension in an organization between technology push focused on long-term research and technology pull from programs, someone is always asking not only "what for?", but also "what if?" and "why not?" An advanced research and technology development mission of NASA would be exploring advanced launch systems in pursuit of low cost access to space; compact nuclear power systems; plasma- and other electric-propulsion concepts; energy storage technology; highly energetic propellants; affordable space-based solar power systems; multi-spectral sensors; advanced space-based communications; closed-loop life-support systems; radiation shielding concepts; highly intelligent and mobile robotics—the list could go on with a host of other areas of research not being addressed in today's constrained environment. And you will not see requirements for such systems, because we do not write a requirement for something no one knows how to do.

NASA should revitalize advanced space technology development as a priority mission area of the Agency. It should engage the best science and engineering talent in the country wherever it resides in universities, industry, NASA centers or other government labs focused on world-class research and innovation and not driven by the need to maintain ten healthy centers. It should support not only future NASA missions, but other government agencies and commercial space. The "customers" for its technology products would be industry, NASA itself, other government agencies like NOAA, and military space where dual-use technology is applicable. Having this broad mandate would make it similar in the breadth of customers served to the NASA role in aeronautics with its heritage in NACA going back almost a century.

That brings me to the aeronautics program where there is good news and bad. Aviation has a major impact on U.S. economic competitiveness and our leadership position in the world. No one questions that it is vitally important particularly in the U.S. in moving people and goods throughout the country and the world. The good news regarding the NASA aeronautics program is the restructured program in fundamental research is stable and providing excellent results. I am particularly pleased with the new emphasis in systems research in this year's request. The Environmental Responsible Aviation (ERA) program builds on the progress in the base research program and begins to address the complex system interactions accompanying the integration of technology to achieve lower fuel consumption, lower emissions, lower noise, improved safety, and greater air-traffic system capacity. These attributes, all desirable in isolation, tend to work against each other when integrated into a system. The newly formed category of Integrated Systems Research, of which the ERA program is the first in the category, enables NASA, in cooperation

with industry and universities, to explore the system advances that will make aviation more energy independent and environmentally friendly. More resources in the out-years would be helpful. The Recovery Act funding that the Congress was able to add to the NASA aeronautics budget this year were very helpful in jump starting this important area of research and it is also being put to good use in facilitating the transition of NextGen focused technologies to the FAA.

This year's budget request is very encouraging and a positive step. However, NASA's investment in aeronautics is a fraction of what it was just a short time ago, and that is the bad news. Ten years ago the aeronautics budget was over three times what it is today in equivalent full-cost accounting terms and today's dollars. Then, it was 10 percent of the total NASA budget. The Congress has consistently recognized inadequate funding for aeronautics by augmenting past administration requests, but unless that level is reflected in the run-out budget request by the administration, the research efforts at the higher level cannot be sustained, year-to-year. More resources would be helpful in areas of system-level testbeds and taking technology to higher readiness levels for the advances in the Airspace Systems and Aviation Safety programs in support of NextGen. Also, it would enable NASA to shift the balance of R&D to be a better blend of in-house and out-of-house research with universities and industry—something the NRC Decadal Survey on Civil Aeronautics also recommended.

Taking aeronautics and space technology together, an investment of at least ten percent of the total agency's budget for advanced *aerospace* technology development focused on forward-looking innovation is not unreasonable, in my view, for a government agency that has a mandate to help maintain U.S. leadership in aerospace science, engineering, research, and advanced technology development. One does not need to go too far back to a time when it exceeded that level.

Coming full circle to my opening comment about having the right program content and the right amount of resources to implement it, I have touched on where I think some of the holes are in program content and underfunded technology and of course the Augustine Committee will untangle the big issues in human space flight. I must be perfectly clear that the areas I mentioned needing more funding cannot and should not be solved by transferring money from other parts of NASA. Every time I look at the current scope of the NASA program and consider what budget level it takes to do it right, I come up with a level of around $22–23 billion for the Agency. This figure is not based on a rigorous, detailed assessment, but a well-informed opinion. It would seem that at this level, NASA's space and aeronautics mission should compete favorably for discretionary resources against other priority national needs, particularly given how it supports many of those needs of broad national interest. Much less than that level of funding means something has to give—some combination of mission scope, program content, schedule, or institutional infrastructure. This subcommittee has taken aggressive steps in the past to recognize the need for increased funding for NASA. I hope the testimony given at this hearing is helpful in your deliberations on the FY 2010 budget.

That completes the remarks I wanted to make and I would be pleased to take questions if you have them. Thank you.

BIOGRAPHY FOR RAYMOND S. COLLADAY

RAYMOND S. COLLADAY is a retired corporate officer of the Lockheed Martin Corporation and the former President of the Lockheed Martin Astronautics company in Denver. Before entering the private sector, he held positions of Director of DARPA—the Defense Advanced Research Projects Agency of the U.S. Department of Defense and was Associate Administrator of NASA where he had senior executive responsibility for the Agency's aeronautics and space research and technology development including operations oversight of Ames, Langley, Dryden, and Glenn Research Centers. Dr. Colladay started his aerospace career at NASA Glenn Research Center in propulsion R&D before moving to NASA Headquarters where he held a number of leadership positions before being appointed Associate Administrator of the Office of Aeronautics and Space Technology. He has been a member of the Air Force Scientific Advisory Board and various Defense Science Board summer studies. Currently, he owns an aerospace consulting company, RC Space Enterprises, Inc.; teaches leadership and ethics for the Colorado School of Mines; and serves on a number of boards, steering committees, and commissions. He received his BS, MS, and Ph.D. degrees in mechanical engineering from Michigan State University and attended the Harvard Business School's Advanced Management Program. He is a fellow of the AIAA and of the American Astronautical Society. Dr. Colladay is Chairman of the Aeronautics and Space Engineering Board (ASEB) of the National Acad-

emies. He has two daughters and four grandchildren and resides in Golden, Colorado with his wife of 44 years.

Chairwoman GIFFORDS. Thank you very much. Dr. Moore.

STATEMENT OF DR. BERRIEN MOORE III, MEMBER, NATIONAL ACADEMIES' SPACE STUDIES BOARD (SSB)

Dr. MOORE. Madam Chairman and Members of the Subcommittee, thank you for the opportunity to appear today on behalf of the Space Studies Board of the National Research Council chaired by Dr. Charlie Kennel. He regrets that he could not be here to provide testimony.

In this verbal presentation, let me turn directly to your questions. First, what are the top priorities and issues that the House Committee on Science and Technology should consider in the upcoming multi-year NASA authorization legislation? In a word, balance. The convergence of pressures could significantly destabilize the overall program. Among these pressures are to complete and utilize the International Space Station, to retire and replace the Shuttle, to define a rational and realizable Moon-Mars exploration initiative, to execute a healthy science program including meeting the scientific challenges of climate change, and finally to restore and realize a healthy aeronautics program.

All of these pressures gather in an overall NASA framework of 10 healthy centers and the Office of Management and Budget (OMB) 2011 level guidance on budget reductions. All of this strikes me, reflecting my mathematical background, as an over-determined problem. It cannot all be done. What will give and how it will give is the central challenge facing the House Committee on Science and Technology and facing us all.

Second, what are my perspectives on the key challenges and opportunities for space science and to what extent does the 2010 budget address them? The 2010 budget is a significant improvement on fiscal year 2009, but we face real challenges. We simply must do more with less and/or do less with what is available, to concentrate the resources. We need to reduce the cost of doing business. Fewer managers managing managers. We need to utilize innovative ideas with significantly lower cost to obtain the needed observations. For instance, use alternative platforms like autonomous aircraft or high-altitude long-stay dirigibles. Use smaller spacecraft and simpler instruments. Avoid the perfect, being the enemy of the good. The opportunity is that with change and challenge, we might find the new path that leads to a greater net good by doing business differently but with honesty. No smoke and mirrors, no cute phrases, but do it honestly and with simplicity.

Third, what are my perspectives on NASA's plans and budgetary outlook for accelerating the implementation of Earth Science Decadal missions, including the use of the Recovery Act funds. Unfortunately as my written testimony details, the best we can hope for is that the delays will be minimized. Almost all of the monies went to pay for increased costs in the pre-Decadal missions, Glory, Landsat Data Continuity Mission, NPOESS Preparatory Project (NPP), the Global Precipitation Mission. If there had been a systemic change such as making the stimulus monies for Earth science a permanent rebudgeting, then the 2011 and subsequent

increases on top of this new base would have provided the necessary profile to execute the Decadal missions. And I would like to call the Subcommittee's attention to Figure 1 in my written testimony.

Simply stated that the hole that was dug for Earth science between 2000 and 2006 is simply too deep to crawl out of. It needs a strategic fix.

Fourth, what are my perspectives on cost growth and schedule slips in NASA's space science and Earth science programs and their implications and NASA's approach to mitigating future occurrences? I fear that the fixes are too little and too late. We need to have the courage, political and otherwise, to terminate programs that grow excessively, but first we need to avoid these programs to start with. I believe that with a vigorous pre-phase A, that is significant up-front monies, for all of the missions, that that is essential. Then if the technical base is not clearly in hand and very realistic budgets available and agreed to, if those pieces are not there, then the mission is parked until it is ready to start. We must avoid doing something on quicksand or even sand itself. We need a granite foundation, preferably from New Hampshire, reflecting my previous life.

Are there any other matters that need attention? There are two. NASA's monies must be multi-year on the commitment side. To go to a one-year commitment process I think would not be wise. And finally, there needs to be some consideration on the reduction in the number of NASA centers. The same could apply for National Laboratories. What was built in one era is not always useful or needed in the next. We have recognized this with military bases. Why not other national facilities?

Thank you, and I look forward to your questions.

[The prepared statement of Dr. Moore follows:]

PREPARED STATEMENT OF BERRIEN MOORE III

Madam Chairman and Members of the Subcommittee, thank you for the opportunity to appear today on behalf of Space Studies Board (SSB) of the National Research Council (NRC), chaired by Dr. Charles Kennel. Dr. Kennel is also a member of the blue-ribbon Review of U.S. Human Space Flight Plans Committee. Dr. Kennel regrets that he could not be here to provide testimony today. I will try to cover most of the same key priorities, issues, challenges and opportunities for NASA's science programs that Dr. Kennel would have presented for you. Although I also serve on the SSB with Dr. Kennel, my views are my own and do not represent an official position of the NRC.

With your permission, I will submit my written testimony for the record and recap briefly my views for you here this morning.

NASA's science programs have been called the Agency's "crown jewel" and with good reason. They represent less than a quarter of NASA's annual budget and only three percent of the annual federal Research and Development (R&D) investment. For this relatively small investment, in recent years, NASA's science programs have provided: critical insights into global climate change and the management of Earth's resources; helped us understand and anticipate the impact of solar storms on our technological infrastructure; changed our views about the potential habitability of other worlds in our solar system and beyond; and revolutionized our understanding of the major constituents of energy and matter in our universe and its eventual fate. In a word, NASA's science programs have enriched our lives, strengthened our societies, and expanded our horizons.

As you consider NASA authorization legislation for the coming years, it is important to keep in mind the potential opportunities that lie in front of the Agency's science programs. On the increasing strength of Earth science, we know can state

that global warming is "unequivocal,"[1] but this simply sets the challenge. We need now to develop the capability to monitor and thereby manage greenhouse gas emissions through the this century and beyond, and concurrently, we need the capability to project with a quantitative understanding of the uncertainties the impact of climate change to at least the regional level, and thereby, provide essential information to help decision-makers mitigate the varying impacts of climate change on local environments and populations.

In solar and space physics, joint observations from multiple spacecraft orbiting in the wake of the Earth may allow predictive models of space plasma and particle interactions to begin to unravel the physics of "magnetic reconnection" and thereby advance our understanding across a range of spatial scales and topics from fusion reactors to black holes. In planetary science, we will have an opportunity to follow-up on the discovery of liquid water environments on Mars and the moons of the outer planets and search for organic compounds and other past or present evidence of potentially life-bearing environments beyond Earth. In astrophysics, we will have an opportunity to follow up on the discovery over the past decade of more than 300 planets outside our solar system and hence expand the search for planets 'more like' our own Earth. There is also an opportunity in astronomy for NASA to cooperate with the physics community to build upon discoveries about the accelerating expansion of our universe and associated energy "creation" and thereby establish the necessary extended observational platforms to understand the nature of the now-termed "dark energy," which apparently dominates the energy budget of the universe and drives its expansion. And in life and microgravity sciences, the International Space Station (ISS) could provide U.S. researchers with their first permanent microgravity research platform.

These are each unique opportunities during our lifetimes for the United States to demonstrate technical leadership, advance the state of scientific knowledge for humanity's benefit, and leave important legacies for future generations. In stating this, I clearly recognize the significantly challenging economic environment, and I am well aware of the out-year budget constraints and recent "Guidelines."[2] The times call for careful setting of priorities; I present this testimony in the knowledge of this necessity.

When considering authorization legislation for the Agency, it is also important to keep in mind how NASA's science programs can be employed as a tool to address national priorities outside the scientific enterprise. For example, in foreign affairs, NASA's science programs have a long history of international cooperation with partners in Europe, Japan, Russia, and Canada. With a number of new space powers emerging around the globe, NASA's science activities provide an opportunity to engage countries like China and India in peaceful, scientific pursuits that could encourage transparency in their space programs. Because they are a demanding consumer of new technologies, NASA's science programs also help address economic competitiveness by driving new developments in critical technologies like instrumentation, autonomy, communications, and data management. And the exciting discoveries made in NASA's science programs are particularly inspirational to youth and easily shared with the Internet and smart phone generation, a potentially important source of new engineers and scientists for our economy. In past legislation, Congress has recognized the value of sharing the adventure of space research via new virtual methods and should continue to do so.

To realize these opportunities, a number of critical issues must be addressed and challenges met. Arguably the largest issue is restoring or at least maintaining the balance of funding between NASA's science and human space flight activities. Several years ago, over $3 billion was eliminated from the Science Mission Directorate budget to help pay for return-to-flight, Space Shuttle retirement, and the Constellation Program. This eliminated the projected growth in NASA's Science Mission Directorate and exacerbated what had already been dangerous downward trends in portions of the science portfolio. For example, after accounting for structural changes in how NASA categorized its budget, the 2007 National Research Council Earth science and applications from space "decadal survey"[3] documented that sup-

[1] "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Fourth Assessment Report (Working Group One) of the intergovernmental Panel on Climate Change.

[2] OFFICE OF MANAGEMENT AND BUDGET; June 11, 2009; MEMORANDUM FOR THE HEADS OF DEPARTMENTS AND AGENCIES: Planning for the President's Fiscal Year 2011 Budget and Performance Plans.

[3] National Research Council, Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (2007), *http://www.nap.edu/catalog.php?record_id=11820#toc*

port for the overall effort for Earth observations and the associated science in NASA was reduced by more than 30 percent between 2000 and 2006 (see discussion below).

Across the Agency, reductions in science support led to the deferment of multiple missions, painful program restructurings, dramatic reductions in research grants, and the elimination of many technology investments. A recent report by the Congressional Budget Office warns that estimates of the cost of NASA's Constellation Program through the first manned lunar landing have risen from $57 billion to $92 billion, and may reach $110 billion. Although the Review of U.S. Human Space Flight Plans Committee is tasked with developing an affordable and sustainable human space flight program that fits within the current budget profile for NASA's human exploration activities, it is a very difficult task and does not guarantee that NASA's human space flight programs will not encounter unanticipated problems and future cost growth. To ensure the productivity of NASA's science programs, it is important that any future growth in human space flight costs not impact the already flat science budget. In the past, budgetary "firewalls" have been erected to protect other parts of the NASA budget from cost growth in human space flight programs, and Congress may want to consider such measures in the future. In doing so, Congress may need to ensure that such firewalls are actually honored.

A related issue is the question of ISS utilization and NASA funding for microgravity research. While a number of the long-promised ISS research facilities are available or will become available in the next year, the number of U.S. investigators currently in a position to exploit the potential of these facilities is very limited. The NASA programs that supported the development of investigations to use these facilities were either canceled or severely cut in the middle of this decade. From 2004 to 2008, the number of life and microgravity science investigators supported by NASA fell from 769 to 230, a 70 percent drop overall with physical sciences research dropping by 90 percent. Many of the small number of U.S.-sponsored ISS investigations that remain were preserved by congressional intervention. Although Congress has designated the ISS as a national research laboratory to encourage its utilization by other federal R&D agencies, Congress should keep in mind that NASA's role, which has declined significantly, in supporting the life and microgravity sciences community to make effective use of ISS remains central and limited. As a consequence, the former research community has largely dissipated, and there are many questions about how high quality research can, or will be, solicited and supported during the window of opportunity we are now entering for ISS utilization.

Turning to the other science-related studies, per Congressional request, the NRC is currently undertaking three decadal surveys—in astronomy and astrophysics, planetary science, and biological and physical science in space. Upon completion, these surveys will have reached community consensus on research priorities that can inform NASA's planning processes and congressional and White House decision-makers. Each of these surveys incorporates inputs from hundreds of researchers. I strongly encourage Members of Congress to closely review these decadal survey reports when they are released, invite their leadership to brief you and your staffs, and reflect their priorities in your legislation wherever possible.

Within NASA's Science Mission Directorate, Earth science is arguably one of its most critical functions and a source of some of NASA's greatest contribution to the Nation. It is also an area where a Decadal Survey had profound impact. As one of the co-leaders of the Earth Science Decadal Survey,[4] I applaud Congress's subsequent increased support for NASA's Earth science program. This support was and is needed.

As noted earlier, despite the wealth of information that NASA's Earth observation research has supplied on understanding climate change, much more is needed. The challenge is growing and will not go away; climate change is not a *problem de jour*. Recognizing the need for increased information, the 2009 Recovery Act was targeted to accelerate implementation of the Earth science decadal missions. I believe that NASA used this money primarily to pay for cost overruns and delays in the existing program, (e.g., LDCM, GPM, and Glory), which could be argued indirectly accelerates (or rather does not further delay) the decadal missions. It could also argue that it rewards poor management.

The Earth science budget in the President's FY 2010 request is a marked improvement over the early budgets. However, it remains inadequate, particularly in the out-years and well below the recommended profile from the Decadal Survey. The following Figure highlights the difficulty (see also Attachment One).

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[4] *Ibid.*

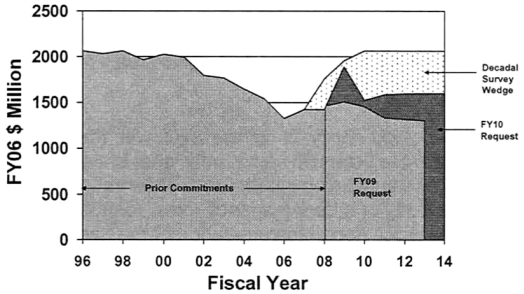

Figure 1. Comparison between the President's FY10 NASA request and the NRC decadal survey recommendation. The spike seen in 2009 is from the Recovery Act.

On the current path only four (SMAP, ICESat-II, DESDynl and CLARREO) of 15 missions recommended by the NRC's Earth Science decadal survey will be launched before 2020. This mission backlog, which I believe the Nation can ill afford, has been exacerbated by the recent loss of the Orbiting Carbon Observatory mission and continuing delays in NPP. Where funding can be added to the NASA science budget, Congress should consider accelerating the remaining missions from the Earth science decadal survey. Congress may also want to consider encouraging NASA to explore more rapid means of obtaining key measurements from space by utilizing smaller spacecraft wherever possible.

Finally, I note that Congressional add-ons can add further stress to the budget:

- An additional $9 million was marked to refurbish the DSCOVR spacecraft's Earth science instruments, even though DSCOVR did not rise to the very high bar set by the decadal survey. (The survey did note that the space environment sensors on DSCOVR would fulfill the pressing need for an operational replacement of the instruments on the aging ACE spacecraft).
- Last year Congress directed NASA to spend $10 million to initiate development of the TIRS instrument. The FY10 budget indicates the LDCM project is now carrying "between $150–175M" to accommodate TIRS. Although very desirable, the cost for TIRS comes at the expense of the recommended program.
- In a separate area, I question the logic in this cost environment of spending whay may eventually amount to $50 million to undertake the feasibility of the Constellation architecture facilitating service missions to future observatory-class science spacecraft.

In closing my extended discussion on Earth science, let me note that there are major strategic issues in Earth science and the associated observations which remain open as we consider how best to provide the needed information to respond wisely to climate change. In the decadal survey, we recommended that:

- The Office of Science and Technology Policy, in collaboration with the relevant agencies, and in consultation with the scientific community, should develop and implement a plan for achieving and sustaining global Earth observations. This plan should recognize the complexity of differing agency roles, responsibilities, and capabilities as well as the lessons from implementation of the Landsat, EOS, and NPOESS programs.[5]

The need for this *overall* Earth observing plan remains.

Returning to the many cross-cutting issues that affect NASA science programs broadly, one of the most critical is mission cost growth. I touched upon the issue of cost growth in my Earth science discussion above, but it is hardly an issue for Earth science alone; it is an issue that has plagued many of NASA's programs for a long time. It is important to note the obvious: the problems induced by cost growth can become acute within a flat budget environment. To pay for cost growth on one mission, the funding for other missions is often deferred, leading to schedule slippage and potential gaps in the overall research enterprise. For example, a recent

[5] I note that Congress is seeking a similar report (See Attachment One—Congressional Record).

NRC mid-decade review of NASA's solar and space physics programs found that very little of the recommended priorities from the prior decadal survey will be realized during the decade in question—threatening the status of the survey's integrated research strategy—partly because cost growth on some missions has delayed their launch as well as the development of other missions. The effect can be and usually is cascading.

There are numerous different explanations for why cost growth occurs, and the pathologies are different for each mission. Some causes, such overly ambitious science measurements and technology assumptions, are self-inflicted. NASA's Science Mission Directorate is taking some steps to correct these issues. One of the long-standing axioms of program management is that it is necessary to spend a significant amount of money on a program in the early concept stages in order to better understand the technology and engineering requirements and tradeoffs.[6] NASA is now doing this for some of its missions. NASA and the NRC are also requiring independent cost estimates—as opposed to estimates produced by a mission's advocates—in the current round of decadal surveys to improve the overall planning process and help to keep mission proposals honest. The NRC is also starting a congressionally-mandated study of the causes of mission cost growth and possible ways to remediate it that may inform future cost management strategies.

However, it is important to also point out that some causes of cost growth originate outside NASA. The engineering development of each mission has a most efficient path to follow, and stable, adequate funding is critical to keeping that efficient path in place. If Congress and the White House do not provide stable, adequate funding levels, the schedule for mission developments are often stretched out, leading to increased mission costs. As discussed above, this has occurred in the Earth science program; the NRC mid-decade review of NASA's solar and space physics programs also found that instability in the funding for NASA's Solar-Terrestrial Probes Program was a key cause of mission cost growth. The budget resources that the White House and Congress provide to NASA must match not only mission objectives, but also how, where, and by whom a mission will be developed and carried out.

An issue related to cost growth is the balance between different sizes of missions. The NRC's decadal surveys universally recommend a mix of small, medium, and large missions in each research area. This allows a field to pursue difficult, long-term, but highly rewarding research goals that usually require missions costing a billion dollars or more, while still infusing the field with new data from regular missions costing hundreds or even tens of millions of dollars. Unfortunately, cost growth on large missions can reduce or eliminate opportunities for frequent, innovative, and risk-taking research by eliminating small mission opportunities, such as NASA's Discovery, Mars Scout, Explorer, and sub-orbital programs. This problem is especially acute where a single large mission development, like the James Webb Space Telescope in astrophysics or the Mars Science Laboratory in the Mars Exploration Program, dominates spending for a particular field or program.

Congress should be vigilant about mission balance in NASA's science programs, encourage NASA to take proactive steps to avert cost growth on large missions as early as possible, protect funding for smaller mission opportunities where possible, and restore funding for smaller mission opportunities when they are temporarily reduced. The NRC is currently undertaking two studies, on suborbital and mission-enabling activities, that will provide additional advice on those NASA programs that provide smaller, more frequent research opportunities.

Another cross-cutting issue that has emerged in several recent NRC reports is the importance of investments in technology development independent of science flight missions. NASA had such programs in the past, but they were largely eliminated due to other budget demands. My colleague, Ray Colladay, has covered this issue in detail in his testimony, but its importance to NASA's science programs should be noted. There are numerous technologies that are essential to accomplishing the goals established by the decadal surveys that are currently at relatively low technology readiness levels. Attempts to develop these technologies within flight mission development projects increase the chances that the missions will go dramatically over budget. In addition, it limits the ability of these technologies to be adapted to a broader set of missions. NASA managers are often reluctant to create separate technology development programs because of concern that they become unfocused and also because they are easy targets for budget cuts when flight programs overrun. However, there is no reason that a well-run and tightly focused technology development program will not work. Congress should encourage NASA to make nec-

[6] In the Earth Science Decadal Survey, we explicitly called for extended and early Phase A studies to provide early understanding of the technology readiness issues.

essary technology investments in advance of mission development starts and protect those investments when they are well-managed and productive.

An issue that has repeatedly appeared in NRC reports on NASA's science programs is the shrinking availability and affordability of launch vehicles. This problem is most acute for medium-sized science payloads that have relied in the past on the workhorse Delta II launch vehicle. As the Air Force moves the Global Positioning System (GPS) to Evolved Expendable Launch Vehicles (EELVs), there may not be enough business to maintain the Delta II line in an operational or affordable state. NASA is encouraging the development of potentially affordable alternatives to the Delta II through its Commercial Orbital Transportation Systems (COTS) program, and these efforts should receive Congress's support. If these efforts do not come to fruition, NASA will either have to make potentially unacceptable technical compromises to fit medium-sized missions on smaller launch vehicles, or pay unnecessary and much higher costs to launch medium-sized missions on larger launch vehicles.

Finally, NASA is both a research and advanced technology development agency. As such, it must continue to have multi-year budget authority (subject to the availability of funds). This is essential.

Like any cutting-edge, highly technical endeavor, NASA's science programs face a number of issues, from both within and without, that must be addressed in a forthright manner to maintain the high productivity of the U.S. civil space program's "crown jewel." I hope my testimony provides you with useful advice on some of the important steps that can be taken to meet these challenges. Given the remarkable advances in NASA's science programs over the past decade, the relatively small investment required, and the opportunities we anticipate in the coming decade, such steps are well worth the effort.

This completes my prepared remarks and I am happy to answer any questions the Subcommittee may have. Thank you.

Attachment One

Issues in Earth Science

The Decadal Survey Committee concluded that the recommended NASA program could be accomplished by restoring the Earth science budget in real terms to where it was in the late 1990s. To track progress since release of the decadal survey, we've continued to update the budget figure shown in the report's Chapter 2. This graph shows—in constant year (2006) dollars—how the NASA Earth science budget has fared over time. It corrects for inflation and accounting changes that have been made over the years, such as the switch to full-cost accounting and the latest change to separately account for so-called "cross-cutting programs" (which fund center operations). This has been done because it puts the budget request in context, and this is needed to compare budgets from different years in an apples-to-apples fashion. The gray portion shows the previously enacted budgets and the FY09 request; the President's FY10 request is shown in purple and includes the $325M that Congress directed to Earth science in the Recovery. Even with this one-time significant infusion of funds, the program is falling short of what the Decadal Survey Committee recommended. The gap between the recommended funding level and out-year projections is both large and persistent. The NASA Earth science program requires an on-going commitment of funding at a higher level if it is to make needed progress on the decadal survey. The program is doing what it can with the resources it has been given—however it has not been given enough to accomplish all that is expected of it.

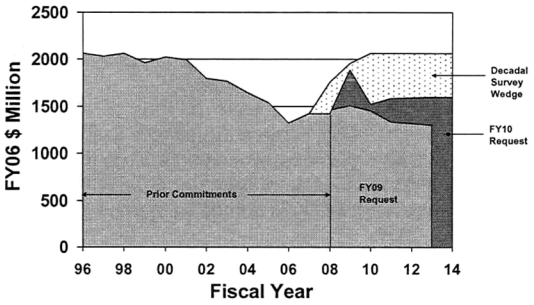

Figure 1. Comparison between the President's FY10 NASA request and the NRC decadal survey recommendation. The spike seen in 2009 is from the Recovery Act.

On accelerating decadal survey missions

The latest budget has the first decadal survey mission (SMAP) launching in late 2013 or early 2014, with a second (ICESat-II) launching in late 2014 or early 2015. In contrast, the decadal survey had recommended launching four missions by 2013. It is my understanding that CLARREO is to be launched in 2019 (12 years after the release of the Decadal Survey). So, what happened? Put simply, the needed budget increase did not happen and existing programs overran. To remain within the allocated profile, NASA stretched out the program.

The Stimulus monies, even though it states an objective of accelerating decadal survey missions, does not seem to be having the intended effect, unless one argues that it prevented further delays. Tracking NASA's weekly reports on its recovery act web site, it does not appear any activity has occurred related to the decadal survey missions; indeed the FY10 budget indicates SMAP and ICESat-II will likely slip rather than accelerate. Perhaps there is more detail in the operations plan that NASA has been preparing, but this is not yet public.

Thoughts on Cost Growth & Schedule Slips

As noted in my testimony, schedule slips and cost growth go hand-in-hand. Changes or increases in scope also tend to be associated with both cost growth and schedule slips. Simply put, the NASA Earth Science program cannot afford any of the above. As mentioned earlier, the program does not have enough funding to accomplish all that is expected of it in a reasonable time frame. When existing missions grow beyond their allocated budgets, the situation becomes that much worse.

Glory's cost grew between the FY09 and FY10 requests as its launch was delayed from March 2009 to January 2010. This brings its development cost estimate to $296M, compared with $259M back in 2008. In terms of life cycle cost, in the last two years it has grown ?$90M.

NPP's launch was delayed again from June 2010 until January 2011 due largely to the late delivery of the VIIRS instrument—the mission was originally supposed to launch in late April 2008. So, instead of NASA Earth science program costs for NPP decreasing as the mission transitions into operations, they are increasing to cover the extended development phase. The change between the baselines development estimate (from 2008) to that reported in the FY10 budget is greater than $130M.

GPM and LDCM are also slipping to the right. What is more troubling is that these two missions are still in formulation. Each of these missions, when you add up the appropriations lines projected through 2014 is at least on the order of $850M (each). It is important to note that some of the cost growth for LDCM comes from unfunded and costly Congressional mandates.

Cost growth in the existing program and early decadal missions greatly imperils the *decadal vision,* which requires multiple measurements covering all aspects of the Earth system. Allowing individual missions to grow in scope at the expense of the program means important missions and measurements will be lost or deferred and intended synergies will be lost. In the decadal survey, we explicitly recommended a firm triage: missions that grow significantly in budget need to be parked in the breakdown lane until they can be placed through descopes or other strong management actions on a more reasoned and restrictive budget profile. If

this is not done, the existing program or early decadal missions will block the realization of the overall program.

References/Screenshots from the NASA budget sections of relevance for NASA budget below for Glory, NPP, GPM, and LDCM

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	218.5	82.3	50.7	27.1	10.1	4.4	1.9	0.0	0.0	395.0
Formulation	70.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.8
Development / Implementation	147.7	82.3	50.7	15.4	0.0	0.0	0.0	0.0	0.0	296.1
Operations / Close-out	0.0	0.0	0.0	11.7	10.1	4.4	1.9	0.0	0.0	28.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2009 President's Budget Request	219.2	35.2	29.7	9.1	9.8	2.7	0.0	--	0.0	305.7
Formulation	70.8	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	70.8
Development / Implementation	148.4	35.2	25.1	0.0	0.0	0.0	0.0	--	0.0	208.7
Operations / Close-out	0.0	0.0	4.6	9.1	9.8	2.7	0.0	--	0.0	26.2
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2009 Request	-0.8	47.1	21.0	18.0	0.3	1.7	1.9	--	0.0	89.2
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Development / Implementation	-0.7	47.1	25.6	15.4	0.0	0.0	0.0	--	0.0	87.4
Operations / Close-out	0.0	0.0	-4.6	2.6	0.3	1.7	1.9	--	0.0	1.9
Other	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.1

Explanation of Project Changes

Cost growth since the FY 2009 Budget is related to the launch delay from March 2009 to January 2010. The reasons for the launch delay, and associated cost growth, were addressed in NASA's Glory Project Cost and Schedule Analysis Report (CSAR) to Congress, as required by Section 103(d)(2) of the NASA Authorization Act of 2005.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Development Cost and Schedule Summary

The base year development cost estimate below is consistent with the revised baseline reported in the Glory Project Cost and Schedule Analysis Report (CSAR) to Congress. At that time, the launch date was estimated to be June 2009. Cost growth since that time is due to the additional delay until November 2009. The Project is making good progress towards the new launch date.

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Glory Mission	2008	259.1	2009	296.1	14	Launch Readiness	6/15/2009	1/23/2010	7

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**259.1**	**296.1**	**37.0**
Aircraft/Spacecraft	31.7	37.5	5.8
Payloads	117.4	138.6	21.2
Systems I&T	3.2	3.8	0.6
Launch Vehicle/Services	55.4	55.4	0.0
Ground Systems	0.9	1.1	0.2
Science/Technology	10.3	12.2	1.9
Other Direct Project Cost	40.2	47.5	7.3

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	542.9	46.1	57.1	112.8	33.8	5.3	5.2	5.1	6.0	814.3
Formulation	47.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.7
Development / Implementation	495.2	46.1	57.1	112.8	28.8	0.0	0.0	0.0	0.0	740.0
Operations / Close-out	0.0	0.0	0.0	0.0	5.0	5.3	5.2	5.1	6.0	26.6
Other	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0
FY 2009 President's Budget Request	554.5	70.0	94.4	46.3	8.6	8.9	9.2	--	11.4	803.3
Formulation	47.7	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	47.7
Development / Implementation	506.8	70.0	94.4	46.3	0.0	0.0	0.0	--	0.0	717.5
Operations / Close-out	0.0	0.0	0.0	0.0	8.6	8.9	9.2	--	11.4	38.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2009 Request	-11.6	-23.9	-37.3	66.5	25.2	-3.6	-4.0	--	-5.5	11.0
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	-11.6	-23.9	-37.3	66.5	28.8	0.0	0.0	--	0.0	22.5
Operations / Close-out	0.0	0.0	0.0	0.0	-3.6	-3.6	-4.0	--	-5.4	-11.5
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	-0.1	0.0

Note: The FY 2010 LCC number in the table above is overstated by $14.9M due to the difference in the FY09 enacted bill and the April 2009 initial operating plan. Assuming approval of the initial operating plan, the estimated NPP lifecycle cost will be $799.4M, and the estimated Development cost will be $725.1M.

Explanation of Project Changes

The changes to the NPP budget are due to the launch delay from June 2010 until January 2011, primarily caused by late delivery of the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument.

Development Cost and Schedule Summary

The VIIRS sensor delivery from NASA's NPOESS partners continues to impact the NPP project. Ongoing issues with the VIIRS sensor development has caused the NPP launch to slip again. The revised NPP launch date is now January 2011 due to the late sensor delivery.

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
NPOESS Preparatory Project (NPP)	2006	592.9	2008	725.1	22	Launch Readiness	4/30/2008	1/31/2011	33

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**592.9**	**725.1**	**132.2**
Aircraft/Spacecraft	160.0	164.3	4.3
Payloads	194.2	162.3	-31.9
Launch Vehicle/Services	72.9	93.3	20.4
Ground Systems	48.2	49.4	1.2
Other Direct Project Cost	117.6	224.3	106.7
Science/Technology	0.0	31.5	31.5

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Global Precipitation Measurement (GPM)

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	74.4	157.8	159.5	127.6	137.5	111.2	80.4
FY 2009 President's Budget Request	74.4	125.8	161.7	129.8	140.0	113.3	--
Total Change from 2009 President's Budget Request	0.0	32.0	-2.2	-2.2	-2.5	-2.1	--

Estimated Project Schedule

GPM entered formulation in July 2002. Milestone dates beyond the formulation phase are preliminary estimates pending completion of formulation.

Milestone Name	Formulation Agreement Estimate	FY 2009 PB Request	FY 2010 PB Request
Development			
KDP-C	Dec 2003		May 2009
Core Observatory launch readiness date (LRD)	Nov 2010	Jun 2013	Jul 2013
Low-Inclination Observatory launch readiness date (LRD)		Jun 2014	Nov 2014

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Landsat Data Continuity Mission (LDCM)

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	127.3	200.9	120.6	137.4	165.0	90.0	15.0
FY 2009 President's Budget Request	133.0	139.4	127.1	96.0	11.3	2.7	--
Total Change from 2009 President's Budget Request	-5.7	61.6	-6.5	41.3	153.7	87.3	--

Starting in FY2009, NASA will develop a Thermal Infrared Sensor (TIRS) instrument, to be flown on LDCM or (potentially) some other spacecraft. A decision as to which spacecraft will carry TIRS will be made by summer of 2009. Meanwhile, funding for TIRS (approximately $150-175M) is now carried within the LDCM budget.

Estimated Project Schedule

In FY 2008, the LDCM Project awarded the LDCM spacecraft contract to General Dynamics and the Mission Operations Element (MOE) system development contract (in coordination with the USGS) to the Hammers Corporation, completing the mission complement.

In FY 2009, the LDCM Project will complete the spacecraft and MOE PDR, and the mission PDR. The OLI will undergo critical design and fabrication in FY 2009 and 2010. System integration and test will begin in FY 2011. Observatory integration and testing, as well as environmental testing, will take place in FY 2011, and launch vehicle integration will begin at the start of FY 2012.

Milestone Name	Formulation Agreement Estimate	FY 2009 PB Request	FY 2010 PB Request
Development			
Formulation			
Award OLI contract	June 2007	June 2007	July 2007
Confirmation Review	Jan 2008	Jan 2008	Dec 2009
Critical Design Review (CDR)	Feb 2009	Feb 2009	Apr 2010
PSR	May 2011	May 2011	Jun 2012
Launch	Jan 2011	Jan 2011	Dec 2012

From the congressional record
Note: Zoomed-in version below

SCIENCE

The bill provides $4,503,019,000 for science, an increase of $61,500,000 over the budget request. The amount provided reflects an unallocated adjustment of $70,898,000 and reflects unobligated balances carried into fiscal year 2009 from fiscal year 2008. NASA shall within 30 days of enactment of this Act provide to the House and Senate Committees on Appropriations its proposed distribution of the unallocated adjustment. In doing so, NASA shall identify offsets that do not result in delays or cancellations of missions in development or the cancellation of any selected projects, and shall not identify as offsets any increases provided above the request expressly provided by Congress.

Earth science.—NASA's Earth science portfolio shall have a continuous mixture of small-, medium-, and observatory class Earth science missions that guarantee regular and recurring flight opportunities for the Earth science communities.

Earth decadal survey missions.—A total of $150,000,000 is provided for Earth decadal survey missions. Funds are provided to support on-going activities of the ICESat II and SMAP missions. In addition, funds are provided to accelerate and achieve a level of system development more consistent with the National Academy of Sciences' recommendations. The bill provides funds to accelerate the ICESat II mission so that it will be ready to launch in 2013 concurrently with the SMAP mission, consistent with the National Academy of Sciences' recommendations.

Landsat data continuity mission (LDCM).—Funding of $10,000,000 is provided to initiate development of a thermal infra-red sensor (TSIS). NASA is directed to identify the earliest and least expensive development approach and flight opportunity for TSIS. NASA shall report its findings to the House and Senate Committees on Appropriations not later than March 2, 2009.

NASA is further directed to develop, in cooperation with the Office of Science and Technology Policy (OSTP) and the U.S. Geological Survey (USGS), a plan for a follow-on mission to LDCM consistent with the recommendations of the National Science and Technology Council's report, A Plan for A U.S. National Land Imaging Program. This plan is due to the House and Senate Committees on Appropriations no later than August 31, 2009.

Earth science applications program.—The bill provides $10,000,000 over the budget request for Earth science applications under the Research Opportunities in Space and Earth Sciences (ROSES) program, which shall be available to support new competitively-selected projects under subsection A 29. Earth Science For Decision Making: Gulf of Mexico Region, to be selected during fiscal year 2009.

Deep Space Climate Observatory (DSCOVR).—The bill provides $9,000,000 for NASA to refurbish and ensure flight and operational readiness of DSCOVR earth science instruments.

Servicing Opportunities for Science Missions.—Recognizing the historic successes NASA has achieved through the servicing of the Hubble Space Telescope, the National Research Council's recent report Launching Science: Science Opportunities Provided by NASA's Constellation System recommends that "NASA should study the benefits of designing spacecraft intended to operate around Earth or the Moon, or at the libration points for human and robotic servicing." This recommendation parallels the guidance provided by section 502 of the NASA Authorization Act of 2008 (P.L. 110–422), which recommends that provision be made for servicing of future scientific spacecraft to the extent practicable. Therefore, it will be critical that the Constellation program demonstrate unique capabilities to maintain synergies between free-flying scientific spacecraft and human spaceflight endeavors. Accordingly, the bill provides $20,000,000 for NASA to undertake an assessment of the feasibility of using the Constellation architecture to service existing and future observatory-class scientific spacecraft, fully utilizing the unique, core expertise and competencies for in-space servicing developed by the Goddard Space Flight Center and its private sector partners for the Hubble Space Telescope. NASA shall provide to the House and Senate Committees on Appropriations a plan for expenditure of this funding no later than 30 days after enactment of this Act.

Lunar landers.—The bill provides, as requested, $10,000,000 for the selected lunar lander.

Mars exploration.—NASA shall continue to engage the Mars community to define missions for the next decade that will lead to a Mars sample return in the 2020s. NASA is encouraged to define a budget profile for the Mars exploration program to support a lander mission and follow-on missions through 2020; consider augmenting technology to be demonstrated as part of the 2013 Scout; and support the small, competitively-selected missions such as Mars Scouts.

Mars science laboratory (MSL).—The bill provides the budget request of $228,331,000 for MSL. Over the past several months, NASA, with the concurrence of the House and Senate Committees on Appropriations, has taken reprogramming actions to address continuing project cost increases and to maintain a launch schedule in 2009, however, slower-than-expected progress, combined with late completion and deliveries of hardware, has contributed to deterioration in schedule performance. As a result, NASA has informed the House and Senate Committees on Appropriations on December 4, 2008, of its decision to delay a 2009 launch. The relative orbital location of Mars and Earth dictates that the next launch opportunity is 2011. However, in order to support a 2011 launch, NASA will need to identify additional resources in the range of $400,000,000. NASA is directed to provide to the House and Senate Committees on Appropriations not later than February 2, 2009, the impact on the project's baseline development cost estimate consistent with reporting requirements of section 103 of the NASA Authorization Act of 2005 (Public Law 109–155), and proposed resource allocations necessary to meet a 2011 launch. A reallocation of this magnitude can be expected to have significant impacts on other projects, and accordingly, NASA is directed to consult with the space science community to ensure its views are taken into consideration in any decision regarding future funding for MSL.

Outer planets.—NASA plans to conduct an outer planet flagship mission in cooperation with the European community, which a launch as soon as practicable. A more detailed plan and projected launch date shall be part of the fiscal year 2010 budget. The bill includes $101,080,000 for the outer planets program, as requested.

Hubble Space Telescope.—The bill provides the full requirement of $207,697,000 for the operations and upcoming servicing of the Hubble Space Telescope.

Astrophysics exoplanet exploration, other missions and data analysis.—An increase of $20,000,000 is provided to continue NASA's efforts in assessing lower cost versions of the Space Interferometry Mission (SIM) and in completing the detailed formulation phase of a "SIM-Lite" mission that would meet the requirements laid out in the most recent decadal surveys for an astrophysics mission.

Radiation Belt Storm Probes.—The bill provides the full budget request of $134,442,000 to continue this mission for launch in 2012.

Solar Probe.—The bill includes $18,000,000 for the Solar Probe mission, the highest priority recommendation of the National Academies' heliophysics decadal report. NASA is directed to work to achieve a launch no later than 2015.

Magnetospheric Multiscale Mission.—The bill includes the budget request of $94,982,000 for the Magnetospheric Multiscale Mission. NASA is directed to undertake no action to de-scope or reduce the project's scientific instruments or capacity.

Wallops Flight Facility (WFF).—The WFF is an important national asset that can be better utilized by focusing on emerging technologies that meet national needs and NASA priorities. The bill therefore provides programmatic increases of $5,000,000 for advanced technology development of small satellites and unmanned aerial systems (UAS) that have the potential of lowering the costs of space and Earth science missions consistent with the goals of venture class missions recommended by the National Academies' Earth science decadal report, and $14,000,000 to improve launch pad infrastructure. NASA is directed to prepare a five-year action plan, including a proposed funding forecast, that identifies specific program and advanced technology development work that will utilize and expand the Wallops Flight Facility's role in the development of small satellites and unmanned aerial systems to meet critical earth science and other space system needs. This plan is due to the House and Senate Committees on Appropriations by June 1, 2009.

Ocean vector wind study.—NASA, working with NOAA and within the funds provided, shall study satellite and non-satellite alternatives for generating SeaWinds-like ocean wind data.

AERONAUTICS

The bill provides $500,000,000 for aeronautics research. The research and development activities undertaken with the augmentation shall not be based on the determination that the investment in an activity would result in a usable or useful product based only on one year's funding. Accordingly, the Aeronautics Research Mission Directorate is directed to provide to the Committees on Appropriations of the House and Senate in NASA's initial fiscal year 2009 operating plan a proposed expenditure analysis of the congressional augmentation to ensure that this investment of funds is devoted to long-term, multi-year research and development activities to support NextGen technology needs and solutions and "green" aircraft.

EXPLORATION

The bill provides $3,505,469,000 for exploration for fiscal year 2009, $5,000,000 over the budget request. The amount provided includes an unallocated adjustment of $18,000,000. NASA shall within 30 days of enactment of this Act provide to the House and Senate Committees on Appropriations its proposed distribution of the unallocated adjustment. In doing so, NASA shall identify offsets that do not result in delays or cancellations of missions in development or the cancellation of any selected projects, and shall not identify as offsets any increases provided above the request expressly provided by Congress.

Constellation systems.—The bill includes the budget request of $1,018,512,000 for Ares and $1,101,436,000 for Orion.

Constellation systems program, heavy lift cargo vehicle.—The bill includes $23,000,000 above the request for Ares V design requirements definition and research and development for a systems requirement review.

Earth decadal survey missions.—A total of $150,000,000 is provided for Earth decadal survey missions. Funds are provided to support on-going activities of the ICESat II and SMAP missions. In addition, funds are provided to accelerate and achieve a level of system development more consistent with the National Academy of Sciences' recommendations. The bill provides funds to accelerate the ICESat II mission so that it will be ready to launch in 2013 concurrently with the SMAP mission, consistent with the National Academy of Sciences' recommendations.

Landsat data continuity mission (LDCM).—Funding of $10,000,000 is provided to initiate development of a thermal infra-red sensor (TSIS). NASA is directed to identify the earliest and least expensive development approach and flight opportunity for TSIS. NASA shall report its findings to the House and Senate Committees on Appropriations not later than March 2, 2009.

NASA is further directed to develop, in cooperation with the Office of Science and Technology Policy (OSTP) and the U.S. Geological Survey (USGS), a plan for a follow-on mission to LDCM consistent with the recommendations of the National Science and Technology Council's report, A Plan for A U.S. National Land Imaging Program. This plan is due to the House and Senate Committees on Appropriations no later than August 31, 2009.

Earth science applications program.—The bill provides $10,000,000 over the budget request for Earth science applications under the Research Opportunities in Space and Earth Sciences (ROSES) program, which shall be available to support new competitively-selected projects under subsection A.28, Earth Science For Decision Making: Gulf of Mexico Region, to be selected during fiscal year 2009.

Deep Space Climate Observatory (DSCOVR). The bill provides $9,000,000 for NASA to refurbish and ensure flight and operational readiness of DSCOVR earth science instruments.

Servicing Opportunities for Science Missions. Recognizing the historic successes NASA has achieved through the servicing of the Hubble Space Telescope, the National Research Council's recent report Launching Science: Science Opportunities Provided by NASA's Constellation System recommends that "NASA should study the benefits of designing spacecraft intended to operate around Earth or the Moon, or at the libration points for human and robotic servicing." This recommendation parallels the guidance provided by section 502 of the NASA Authorization Act of 2008 (P.L. 110–422), which recommends that provision be made for servicing of future scientific spacecraft to the extent practicable. Therefore, it will be critical that the Constellation program demonstrate unique capabilities to maintain synergies between free-flying scientific spacecraft and human spaceflight endeavors. Accordingly, the bill provides $20,000,000 for NASA to undertake an assessment of the feasibility of using the Constellation architecture to service existing and future observatory-class scientific spacecraft, fully utilizing the unique, core expertise and competencies for in-space servicing developed by the Goddard Space Flight Center and its private sector partners for the Hubble Space Telescope. NASA shall provide to the House and Senate Committees on Appropriations a plan for expenditure of this funding no later than 30 days after enactment of this Act.

Chairwoman GIFFORDS. Thank you very much, Dr. Moore. Mr. Stevens.

STATEMENT OF MR. J.P. STEVENS, VICE PRESIDENT FOR SPACE SYSTEMS, AEROSPACE INDUSTRIES ASSOCIATION (AIA)

Mr. STEVENS. Thank you, Chairwoman Giffords, Ranking Member Olson, and Members of the Committee. I really appreciate the opportunity to testify before you today.

AIA is the largest aerospace association in the United States. We represent nearly 300 manufacturers, over 660,000 highly skilled jobs, and we indirectly support over two million middle-class jobs and 30,000 suppliers from all 50 States. Our member companies also routinely post the Nation's largest manufacture and trade surplus. We appreciate the efforts of Congress to keep the U.S. Space Exploration policy on schedule. This policy remains essential to reducing the U.S.-human space flight gap between the retirement of the Shuttle and the launch of Ares-1 and Orion.

NASA Science Directorate provides us a better understanding of our Earth and universe and NASA's aeronautics research development projects are crucial to the completion of the next generation air transpiration system.

Additionally, NASA's endeavors remain an inspiration for our youth to enter our workforce. We strongly support the current proposed NASA budget of $18.7 billion. However, we are concerned about the out years which are completely flat through 2013.

In addition to ensuring stable and robust funding, we make the following observations and recommendations. In the area of explorations, we believe the current policy should be given the support it is needed to keep on schedule. Over the past five years, the Constellation Program has moved forward, and a great deal of progress has been made. It is now bending metal, it is conducting critical tests, it has produced many jobs that are not only shovel-ready, they are also brain ready.

While we are pleased with Constellation, we are concerned about a couple of other programs. The budget request only provides $25 million a year for Ares-5 and zero funding for the lunar lander. Without moving forward on these vehicles, NASA and industry run the risk of losing thousands of jobs forever.

Another important element to our Space Exploration policy is the International Space Station which is almost complete and could be conducting possibly ground-breaking research in the very near future. It will also provide valuable lessons for our future voyages as it functions much like a test lunar outpost or a test long-duration spacecraft. Most importantly, the International Space Station is a prime example of international cooperation in space. We urge the Committee to maintain the International Space Station at least through 2020 without taking away from other critical NASA programs.

We also recommend Congress to continue to support NASA's use of commercial launch services and on-orbit services to the International Space Station when they are available.

In the area of NASA Science and Earth Observations Programs, we believe NASA's Science Mission Directorate is doing important work given the current concerns about global climate change. A

healthy science program provides valuable information about the cosmos, and NASA's Science and climate change research and development programs provide NOAA with operational weather and climate monitoring satellites. We ask Congress to provide stable funding required to sustain these and our next generation systems.

In regards to aeronautics, AIA believes that NextGen is critical to continuing the decrease in the environmental impact of aviation. Innovative engine design, air frames, avionics, and materials have resulted in a 75 percent reduction in noise and a 70 percent improvement in civil aviation fuel efficiency. These advances spurred by NASA-funded R&D have brought the aerospace industries a long way, and the mission directorate has been responsible for safety and efficiency initiatives that have saved countless lives.

The fourth area I would like to address is workforce. AIA member companies are investing an average of $10 million a year on STEM education, including Team America Rocketry Challenge which is the largest rocket contest in the world. Despite the opportunities NASA's education programs aspire to inspire our youth, we are disappointed with the President's request for NASA education initiatives which is $43 million below the fiscal year 2009 enacted funding level.

The last area is commercial space launch indemnification which will expire at the end of this year. Over the past 20 years, competition from foreign providers who all benefit from some sort of government indemnification has grown significantly. We believe that elimination of U.S. Government indemnification will drive even more launch business overseas. We recommend Congress remove the current gap of $1.5 billion and eliminate the sunset provision. At a minimum, we request indemnification be extended another five years.

In conclusion, space technology has become an important part of our economy, our national security, and our future. NASA stands front and center as the most visible representation of the U.S. Space Program. Its continued work deserves the support from this Committee and Congress. And I thank the Committee for their time and attention. I would be happy to answer any questions.

[The prepared statement of Mr. Stevens follows:]

PREPARED STATEMENT OF J.P. STEVENS

Introduction

Good morning Madame Chairman Giffords, Ranking Member Olson and Members of the Subcommittee. I am grateful for the opportunity to testify before you today on such an important topic as the NASA Reauthorization bill.

As the largest aerospace trade association in the United States, the Aerospace Industries Association (AIA) represents nearly 300 manufacturing companies with over 660,000 high-wage, highly skilled aerospace employees across the three sectors: civil aviation, space systems and national defense. This includes over 140,000 workers who make the satellites, space sensors, spacecraft, launch vehicles and ground support systems employed by NASA, DOD, NOAA, NRO and other civil, military and intelligence space efforts. Our member companies export 40 percent of their total output, and we routinely post the nation's largest manufacturing trade surplus, which was over $57 billion in 2008. Aerospace indirectly supports two million middle class jobs and 30,000 suppliers from all 50 states. The aerospace industry continues to look to the future, investing heavily in research and development, spending more than $100 billion over the last 15 years.

AIA appreciates the efforts of the Congress to keep the requirements of the Nation's historic U.S. Space Exploration Policy on schedule. The policy remains essential to reducing the U.S. human space flight gap between the retirement of the

Shuttle and the launch of the Orion-Ares I, as well as completion of and access to the International Space Station. NASA's Science Directorate provides a better understanding of our Earth and the universe. NASA's Aeronautics Research and Development endeavors are crucial to the completion of the Next Generation Air Transportation System (NextGen) and continued efforts to reduce aviation's environmental impact. Additionally, NASA's work remains an excellent inspiration for our youth to study science, technology, engineering and mathematics and to enter our aerospace workforce on which much of our nation's transportation, security and satellite infrastructure depend.

Recommendations for the 2009 NASA Reauthorization Bill

AIA was extremely pleased with the 2008 NASA authorization bill and the overwhelming bipartisan support it received. As this committee works to shape NASA's policies moving forward, AIA would like to see continued support across all of NASA's mission directorates. NASA's budget must continue to reflect both adequate and stable.

We strongly support the current proposed NASA budget of $18.7 billion, as we believe this is an excellent starting point for NASA funding over the next several years. However, going forward the President's budget is completely flat through 2013. We ask for Congressional support in communicating to the Administration the need for a more robust NASA budget over the next several years. We urge the committee to have policy drive the budget, rather than have the budget drive policy.

We are also very concerned about the recent House Appropriations Committee decision to withhold increased funding for human space exploration pending the results of the Augustine Committee on the future of the U.S. manned space flight missions. Given the implications of delaying our space flight program further, AIA is concerned about any delays that withholding this funding may cause. Our main question is: from where will the additional funding come if the Augustine Committee recommends that NASA continue to stay on course? We fear that no additional dollars will be available from the appropriations committee and progress on this important program will yet again be delayed.

In addition to ensuring a strong and balanced budget, AIA makes the following recommendations on specific areas that should be addressed in the authorization bill.

Recommendation 1: Keep U.S. Space Exploration Policy a Priority

Both the U.S. Space Exploration Policy and the Constellation Program should be treated as national priorities and given the support needed to keep development on its current schedule and to minimize the impending gap in U.S. human space flight.

In January 2004, NASA adopted new far-reaching goals that point toward a next generation human spacecraft, returning humans to the moon and looking toward Mars and destinations beyond. Our industry finds these goals thoughtful, technically feasible and marked with reasonable milestones. Over the last five years, the Constellation program has steadily moved forward and a great deal of progress has been made. NASA has weighed the options on how to best accomplish its goals, designed a strategy and architecture, has awarded several major contracts, and along with industry has lined up the talented individuals needed for these tasks. The Constellation Program is "bending metal" and conducting critical tests. This has produced jobs that are not only "shovel ready" but also "brain ready."

While AIA is pleased with the progress of Constellation so far, we are deeply concerned about the budgetary implications for the future of the program. The FY 2010 budget request for NASA provides only $25 million a year for the Ares V heavy-lift vehicle and zero funding for the lunar lander. Even small delays to current plans may cause NASA and the aerospace industry permanent loss of human capital and reduce options for retaining the specially trained and skilled workforce from the retiring Shuttle program. Without moving forward on these vehicles NASA and the space industry face losing a workforce with vital and unique skill sets to non-space projects or even to other industries. Those taking jobs elsewhere may not return should future jobs in our industry become available.

Another important element to our national space exploration policy is the International Space Station. Final completion of the station is approaching and its crew capacity is now at six. This U.S. National Laboratory is ready to conduct unique and possibly ground-breaking research. The ISS will provide valuable lessons for future voyages to the Moon and beyond, as it functions much like a lunar outpost or a spacecraft on a long duration flight. Most importantly, the ISS is a prime example of international cooperation in space. Sharing expertise and costs with other nations will be critical for future long-duration space missions and the ISS provides a platform to continue to build international cooperation.

We urge the Committee to maintain the ISS at least through 2020 by authorizing the appropriate levels of funding without taking away from other critical NASA mission objectives. We also recommend Congress continue to support NASA's use of commercial launch services and on-orbit services to the ISS when they are available.

Recommendation 2: A Robust NASA Science Program and Addressing the Nation's Earth Science and Earth Observation Programs

The work being done in NASA's science mission directorate is another critical mission area for NASA, particularly given the current political and scientific concerns about global climate change. NASA's science program is perhaps best known for its host of satellites and robotic probes that have combed the outer limits of our solar system. A host of early satellites preceded our human space flights. The Ranger and Surveyor series preceded our Apollo astronauts to the Moon. And we have rovers on Mars and probes that have visited or are en route to all the planets in our solar system. These programs are a necessary precursor to human space exploration and must be sustained.

A healthy science program at NASA not only provides valuable information about the cosmos, but also crucial data on the Earth's ecosystem. NASA's earth science and climate change research and development programs provide NOAA with valuable operational weather and climate monitoring satellites.

It is incumbent upon Congress to provide a stable level of funding required to sustain robust, operational monitoring systems and investing in next generation, R&D Earth observation systems. Further, the NASA authorization bill should continue to provide the framework for the transition of these R&D programs to operational status whenever possible, and Congress should provide OSTP, NASA and NOAA every tool necessary in developing a process to appropriately transition these missions. Private sector capabilities should also be employed to the maximum extent possible to enable improved delivery of observations and decision support tools.

Recommendation 3: A Healthy NASA Aeronautics Program

Historically, AIA and academic research organizations have expressed concern over the amount of focus placed on NextGen-related research and development. While NASA is uniquely positioned to undertake this crucial R&D work, the Aeronautics Research Mission Directorate (ARMD) has failed to keep pace with NextGen R&D requirements to date, leaving FAA to fill the breach. NextGen is critical to continuing the dramatic decrease in the environmental impact of aviation by applying technology and operational improvements that lower emissions. Federal R&D funding is the cornerstone of the advancement of NextGen, with NASA doing work that is then directed to FAA or to industry for further refinement.

Addressing climate change is high on everyone's agenda, including those of us in aerospace. We at AIA see NextGen and environmental improvement as inseparable. Delays in today's air traffic control system result in millions of gallons of fuel wasted annually. For instance, more than 4.3 million hours of delays in 2007 consumed an additional 740 million gallons of jet fuel, costing carriers more than $1.6 billion.[1] This produced approximately 7.1 million metric tons of carbon dioxide.[2] Manufacturers are designing and building 21st century aircraft. However, our air traffic system has not moved into the 21st century—it is virtually the same system in which the noisier, dirtier aircraft of the 1960s flew.

NextGen transformation is key to amplifying aviation's progress in reducing noise and emissions concerns, which are major issues in local communities. Innovative engine design, airframes, avionics and materials have all resulted in a 75 percent reduction of noise and 70 percent improvement in civil aviation fuel efficiency since the late 1960s. These technological advances, spurred by NASA-funded R&D, have brought the aerospace industry a long way, and we are accelerating our programs. NextGen will build on that progress, which is a particular challenge given projected traffic growth and global concern about aviation's effect on the environment.

AIA is pleased to see NASA directing effort towards Integrated Systems Research, which should include modeling and simulation work. This work will greatly expedite NextGen and its layered implementation, including incorporating Unmanned Aerial Systems (UAS) into the civil airspace. Once NASA and the implementation agencies identify the development priorities, industry is committed to leverage its full arsenal of expertise towards the development of the NextGen system.

Moving forward, AIA remains concerned with the Administration's FY 2010 budget request and is committed to working with NASA to pursue mutually beneficial

[1] Your Flight Has been Delayed Again, Delay measurement excludes padding of block times to increase on-time performance; p. 3.

[2] *Ibid.,* emissions during taxi and flight time, p. 5.

research initiatives. Dating back to the early days of NASA aviation aeronautics R&D, the mission directorate has been responsible for revolutionary safety and efficiency initiatives that have saved countless lives. We appreciate this committee's acknowledgment of this tradition of excellence in the FY 2009 NASA Authorization.

Recommendation 4: Continue to support NASA's role in education and workforce development

AIA members have identified that a "lack of trained technical workforce for the future" is one of the most important long-term issues facing our industry. Our companies are taking action to develop the future workforce, each investing on average $10 million a year on science, technology, engineering and mathematics (STEM) education initiatives nationwide. NASA's programs are not only important for its own workforce, but also our industry. As the National Research Council (NRC) stated in 2008, "NASA has a unique and important role to play in motivating and inspiring students to consider STEM careers."

We are encouraged by NASA's FY 2010 education priorities. In particular, we support programs stimulating competitive research that prepares young people for future employment with student activities that are directly tied to real-world experiences (i.e., Constellation, Mars Exploration; global climate change; aeronautics). It is also important to provide opportunities for student flight projects to gain access to space through partnerships with NASA Centers, universities and industry.

Despite the tremendous opportunities NASA's education programs provide towards inspiring our youth, we are disappointed that the President's FY 2010 request for NASA education initiatives is only $126 million. This is particularly disappointing when you consider that just one of AIA's companies spends $60 million on STEM programs. The funding request for FY 2010 for NASA education initiatives is $43 million, or 25 percent, below the FY 2009 enacted funding level of $169 million.

Recommendation 5: Renewing the Commercial Space Launch Amendments

Since 1988, the U.S. Government has had a risk allocation regime that has addressed the exposure of companies providing FAA-licensed commercial launch services to third party liability resulting from launch-related activities. While the U.S. launch industry is considered mature, our launch providers—whether commercial or government—operate within narrow margins of return on their endeavors. Over the last 20 years, competition from foreign launch systems and providers—all of which benefit from some form of government indemnification—has grown significantly. Elimination of U.S. Government indemnification would drive even more launch business overseas. In a competitive market with narrow returns, the loss of indemnification could cause U.S. companies to reconsider the risks and benefits of staying in the commercial launch business and suspend activities or even exit the market. This could also impact launches of U.S. civil and national security payloads. This regime has been extended by Congress four times, but it will expire at the end of this year.

AIA recommends that Congress remove the amendment's tier two cap of $1.5 billion and eliminate the sunset provision in advance of its expiration on December 31, 2009. AIA believes that, at a minimum, the amendment should be extended another five years.

Conclusion

Over the last 50 years, space technologies have increasingly become an important part of our nation's economic, scientific and national security capabilities. Over time, all sectors of the U.S. economy have become inextricably reliant upon space systems. As other nations make rapid advancements in acquiring or exploring space capabilities, America's leadership in space is no longer guaranteed and the securing of its space assets is no longer assured.

NASA stands front and center as the most visible representation of the U.S. space program. It's continued work in space exploration, aeronautics research and development, Earth and solar system observation, scientific research, and manufacturing technology programs remains of critical importance to America and deserves the utmost support from Congress.

I thank the Committee for their time and attention and would be happy to answer any questions.

BIOGRAPHY FOR J.P. STEVENS

JP Stevens is Vice President, Space Systems at the Aerospace Industries Association, which represents the Nation's manufacturers of commercial, military, and business aircraft, helicopters, aircraft engines, missiles, spacecraft, material, and related components and equipment.

Mr. Stevens is in charge of all space policy for AIA, including national security space, commercial space, and civil space. He also serves as Co-Chair of AIA's Space Council with his corporate counterpart.

Before assuming his present position in January 2005, Mr. Stevens served in a number of leadership roles in AIA, including Director of Space Operations, Assistant Vice President of Supplier Management, and Vice President of Special Projects. He also created and served as Executive Director of the world's largest rocket contest, the Team America Rocketry Challenge, an important event to attract middle and high school students to aerospace careers.

From 1994 to 1999, he was a congressional advisor to former U.S. Senator John Glenn on defense, military space, and domestic issues. Prior to that, Mr. Stevens was a career officer in the United States Marine Corps, where he served in numerous aviation and acquisition positions, including as a Naval Flight Officer in operational A–6E squadrons, the Program Manager for Night Attack and Reconnaissance Systems in the F/A–18 Program Office, and Requirements Officer for all Marine fixed-wing ordnance.

He is a graduate of the University of California at Los Angeles, the Marine Corps' Command and Staff College, and the Defense Systems Management College. He resides in Alexandria, Virginia, with his wife Holly Kinnamon, and sons, Henry and Graham.

DISCUSSION

Chairwoman GIFFORDS. Thank you, Mr. Stevens, and thank all of you. It is a very diverse group of witnesses, but there is one common thread which is competence and also commitment.

It is always tough here in the Congress where you take experts who have dedicated their careers and decades to a certain area of interest and then to limit testimony to five minutes and then have to even cut that a little bit short. But we are glad that you are here and in particular these advisory panels on which you serve are voluntary, and the fact that with all the competing demands that you have on your time that you and your colleagues are willing and able to commit the time is vitally important to our nation and is something that this subcommittee plans to continue to utilize your expertise and your education to the commitment that we have toward future exploration.

We do not have a lot of time. Just so everyone knows, the plan is to get a couple of quick questions in, and then I believe that most of our witnesses can reconvene at 1:30. And Mr. Olson, you are okay at 1:30 as well, correct? Okay. So with that, I am going to yield my five minutes to Mr. Griffith who will not be able to come back at 1:30. So Mr. Griffith, five minutes, please.

Mr. GRIFFITH. Madam Chair, thank you, and panel, thank you. We are obviously admirers of you all and human space flight, and we recognize that my district, which we consider in my district the birthplace of human space flight, Fifth of Alabama, we have a great interest in it. We believe that the Saturn V was the Eighth Wonder of the World. We think Ares-1 and Ares-5 will be another wonder.

Are we satisfied, Mr. Marshall, Dr. Ford, that NASA has done all it can to minimize the human space flight gap within its current budgetary constraints and mission requirements? And the second part of that is do we have an inventory of scientists who have

worked on human space flight and where they are and how difficult might it be to reassemble them in a timely fashion?

Dr. FORD. I will take it. Yes, I do think that NASA has done all that it can do given the budget environment that they work in to eliminate or shorten the gap as much as possible. There is going to be a gap, but I think they have done all that could reasonably be asked to do.

In terms of an inventory of space scientists and rocket scientists, I presume, I am not sure if there is such a thing. I do know that folks that worked on earlier programs, including Apollo, are engaged in advising NASA with respect to Ares-1 and -5.

Mr. MARSHALL. Let me add from a safety perspective, I also agree from a safety point of view they have done everything that they can with the resources that they have to minimize the gap. There is no question that there is a gap. It is a lengthy gap. It appears to be getting bigger, not smaller, but there is only so much that you can do with the resources that have been allocated.

The second issue is on workforce management. I will take a little bit of a different stand. I think that we have work to do, the Agency has work to do to catalog and make sure that there is clear understanding of where those resources will be available if they need to be at a later date. While we think the Agency has done a great job of putting time and effort into there, we also think from a safety perspective that there is more work to be done if the Shuttle program were to be extended or expanded.

Mr. GRIFFITH. Generally to the entire panel, do we as a nation, believe that the Chinese would like to get to the Moon before we do, and if so, do we believe as a nation that they are working diligently to do that? Anyone like to take that one?

Mr. STEVENS. I will go ahead and take it. I believe they definitely are, and I think if you take a look at their progress so far and compare it to what we did in the Gemini and Apollo missions, they are making significant progress, and they are using technology that is obviously a lot better than we had back in those days. And I think their goal is set on that, and I think if we don't move along, fund our human space program, we are going to be watching them land for us.

Mr. GRIFFITH. I couldn't agree more, and I think that our committee and those in the audience, our worst nightmare is to be at home in our living room watching the evening news and as the landing occurs, it occurs to everyone in the world that it is the Chinese and not America. And we have an opportunity here, but we have got to keep ourselves focused and we have got to realize we cannot do this on the cheap. This is not something we can do in an inexpensive way. But we appreciate each and every one of you for being here. Thank you.

Chairwoman GIFFORDS. Thank you, Mr. Griffith. Mr. Olson.

Mr. OLSON. Thank you very much, Madam Chairwoman. And I have got a question sort of like my colleague, Mr. Griffith, just for all of you to answer, but later today, you heard the buzzers, but we are expected to pass the fiscal year 2010 appropriations bill for NASA, and as you all know, that proposes to cut funding $670 million for the Constellation Program. And the sponsors of the bill, we have had numerous discussions with them, and I appreciate the

Chairwoman's role in that as well, they have promised us that they will work to restore that funding pending the decision of the Augustine Commission. And my concern there, and what I would like to get your opinion on from a program perspective, what management challenges does this approach impose on the program and the contractors and can we avoid layoffs if the report comes out in the September, October timeframe? Anybody wants to fire up?

Dr. FORD. I think it is very unfortunate and is likely to indeed lead to layoffs. The exact number is unclear. I would hope that that provision would not stick, but if it did it would be problematic. Also, the language about one-year money is highly problematic.

Mr. MARSHALL. Let me——

Mr. OLSON. Mr. Marshall, go ahead, sir.

Mr. MARSHALL. Let me add again from a safety perspective when you see turbulence within the budget process that creates an on-again, off-again, it always creates a threat to the safety, stability. We have seen that in numerous programs before. We have documented that repeatedly, and this particular cut we believe will have significant consequences to the Agency and being able to stabilize. And in fact, if there was any one theme that I heard from this panel this morning, it was the need to stabilize, to balance, and to provide financial supportability to be able to do all of those things, and it just can't fit right now.

Mr. OLSON. Dr. Colladay, did you want to respond?

Dr. COLLADAY. I was actually going to say exactly the same thing. Stability is——

Mr. OLSON. Stole your thunder.

Dr. COLLADAY. Stability is so critical to the endeavors that NASA pursues, and the turmoil caused in the workforce and by schedules being disrupted by reductions when there aren't enough resources in the first place to do what I think is on NASA's plate is terribly disruptive. And I hope that it can be restored and then some.

Mr. OLSON. I share your optimism as well. Dr. Ford was kind of reading my mind by getting ahead, but I just wanted to talk to all of you about the conversion in the appropriation account from a two-year account to a one-year account. I mean, do any of you feel that that is going to be a positive development for NASA, or do we need to stay on a two-year accounting? Everybody is nodding their heads.

Dr. FORD. It is a very, very bad idea.

Dr. COLLADAY. Absolutely.

Mr. MARSHALL. I think that is essential.

Mr. OLSON. I agree with that. And with that, those are all my questions, Madam Chairwoman. I would like to yield the rest of my time to my colleague from California, Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, and I would just like to pose a question that I will be coming back to at 1:30, and I would give you this time to think about it and then to answer when I get back because it is a very simple question. When we are trying to figure out what to do with the NASA budget, it is always very easy to come in and say, well, we are lacking this much money. We are $3 billion short of what we need. Maybe you could give us some specific guidance. What are your areas in the NASA budget that are of highest priority to you? What are your areas of the NASA

budget that are the least priority? And I would expect an answer to both of those questions because it is very easy to say what you want to spend the money on, but where should we look, what areas of the NASA budget has your least support? Should we be losing centers? What center should be closed? Or what program should we bolster? But we need some guidance on both of those issues, and if you could give me a very quick answer when we return, that would be very helpful to us. Thank you very much.

Chairwoman GIFFORDS. Thank you, Mr. Rohrabacher and Ranking Member Olson. We have two minutes and 23 seconds left to vote, so we are going to run out of here. We are going to recess until 1:30, and we look forward to the Members rejoining and our witnesses as well. So until 1:30.

[Recess.]

Chairwoman GIFFORDS. This hearing will come to order. We will submit my opening statement and Mr. Olson's opening statement for the record, and the record will remain open for two weeks for any additional statements from the Members and for any questions the Subcommittee may ask of the witnesses.

The hearing is now adjourned.

[Whereupon, the Subcommittee was adjourned.]

Appendix:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by John C. Marshall, Member, Aerospace Safety Advisory Panel, National Aeronautics and Space Administration (NASA)

Questions submitted by Chairwoman Gabrielle Giffords

Q1. At the hearing, in response to a question regarding either staying on a two-year accounting scheme or converting to a one-year account as is being proposed by the House Appropriations Committee, you indicated that it was essential that NASA stay on the two-year scheme. Please elaborate on why you believe this is essential, especially as it relates to safety.

A1. As noted previously, the ASAP believes that changing NASA's accounting from a two-year scheme to a one-year scheme has the possibility of causing financial turbulence, thereby challenging the Agency's stability. Two-year accounting allows for a program to have more continuity, year to year, than a one-year budget cycle. Research and Development (R&D) programs need longer wavelength budget cycles in order to be effective.

In an R&D environment, requirements are not sufficiently defined at the beginning of each fiscal year to contract for all services in advance, nor are development cycles uniform or predictable across program elements. In this regard, it is critical to retain flexibility to contract for new activities only after the requirements have been fully identified and properly scoped, a process that occurs incrementally throughout the year as projects develop. More importantly, maintaining a critically robust and timely safety program necessitates sufficient budget flexibility to provide for rapid response to risks as they are identified and test failures as they occur.

Maintaining the two-year appropriations accounts provides the foundation for NASA to best manage costs, while successfully executing its programs and projects to achieve mission success.

Q2. Two consecutive Soyuz off-nominal re-entries prompted your annual report to indicate that the Panel remains concerned about the safety of Russian Soyuz spacecraft. NASA has acknowledged that the separation failures "are still unexplained anomalies." *Since we plan to use the Soyuz spacecraft until 2015, do we need closure on these anomalies?*

A2. Even though the root cause for these anomalies cannot be proven, the Russians have instituted several changes to correct the known potential causes of the observed failures. These changes include: adding pyro wire separation; additional grounding and electromagnetic interference protection; additional instrumentation to try to isolate the failure; and installing improved pyrotechnic bolts. These new bolts are a more modern design and have improved electrical performance. Just as important, the Soyuz design is inherently stable during reentry, even with anomalies such as were experienced.

NASA has participated in many of the investigations and performed analysis that supports the general approach that the Russians are using to mitigate concerns from these anomalies. Likewise, the Russians have approached this problem in a similar manner to which NASA would approach such an unexplained anomaly. Based on NASA reports on the Russian corrective actions, the ASAP believes that the mitigation efforts, plus the robust design margins built into the Soyuz vehicle, can support safe recovery operations.

Q3. In his response to ASAP questions, Mr. Scolese, commented that "ISS—NASA's best kept secret is just how hard it is, and will be, to keep station operating safely for the long run without a major adverse event." *What, from a safety standpoint, is needed to ensure long-term safe operations and utilization of the ISS?*

A3. Safety is a unique combination of good equipment, good training, and good execution. NASA and its ISS partners need to be constantly vigilant that all the equipment in the ISS works per design and any unusual incidents are investigated, studied fully, and adjustments are made quickly. The training of the ISS crews is also ongoing, and this is a strength. Lastly, it is important to never become complacent. The primary constraint for executing such a balanced approach is having sufficient budget flexibility to maintain a robust response capability.

Q4. The ASAP report identifies the need for NASA facility maintenance and upgrading as a critical issue for the Agency. How serious is the problem of aging NASA infrastructure and what is needed to address the issue? What are the implications of not addressing these issues with NASA's infrastructure?

A4. The agenda for each ASAP meeting held at NASA Centers includes a walk-around to view first hand activities provided by the Center. During these walk-grounds we are seeing facilities of the Apollo and NACA era used in the early days of Shuttle testing again being used for Constellation projects. Evidence of years of neglect in water main breaks, burst pipes, roof leaks, HVAC system failures, electrical substation or other feeder system failures are common. There likewise is a very serious problem associated with maintenance of supporting institutional facilities and the infrastructure for utility systems, including high pressure gases, steam, water, electrical systems and high voltage, etc. The impact of such failures can range from short-term work disruption and delay to damage to flight hardware and threats to safety.

Reacting to unplanned, emergency repairs is very expensive, and further depletes NASA's ability to perform preventive maintenance and facility renewal. Direct programmatic funds are being expended to take care of major maintenance and upgrades needed in facilities where flight hardware may be at risk.

The ASAP's visit to Glenn Research Center (GRC) provides an excellent example of the implications of not addressing the maintenance and upgrading issues with NASA's infrastructure. Glenn is one of NASA's older centers, and there had been plans, not long ago, to close the facility. As a result, maintenance programs were dropped. Therefore, the challenge now is to rejuvenate aging buildings and roadways, while at the same time undertaking new construction. An example of older equipment now in need of attention and for which there are safety-of-personnel issues are pressure vessels at the Center, some of which require engineering for proper maintenance and pressure re-certification. Further complicating these efforts is that engineering documentation for a large portion of the pressure system infrastructure has been lost over the years, and it needs to be re-developed. Another example of the institutional infrastructure problem at GRC was a break in a major water main that caused the entire Center to be closed down because of the loss of fire protection systems. This shutdown resulted in considerable loss of productivity and a significant cost to the Center.

Since most of NASA facilities are more than 40 years old, they are becoming increasingly more expensive to operate as well as maintain. Also, NASA's initiative to remove unneeded and aged facilities is one that the ASAP supports, but to reduce operating costs in the long term, incurred demolition costs can be very expensive. The result is that deferred facility maintenance associated with the institutional infrastructure continues to increase to offset increasing costs in facility operation and demolition in NASA's operating budget. In lieu of a budget increase to fund these deferred costs, NASA personnel, valued facilities, and productivity may be placed in jeopardy without careful scrutiny of the overall risks.

Significant additional resources are needed to address this serious problem. The implication of not addressing the issue is a steadily increasing risk of failure of major facility systems.

Q5. The FY 2010 Commerce, Justice, Science, and Related Agencies spending bill recommends the consolidation of all institutional and programmatic construction. In your opinion, is that a good idea or would it have unintended consequences. What impact would the proposed funding account consolidation have on the ability to ensure that facilities receive needed improvements in an expeditious manner? Is there a need for a targeted agency initiative on facility maintenance and modernization?

A5. The ASAP has no basis on which to provide counsel on this question as it is outside the panel's focus.

Q6. The Panel's annual report lists, among NASA accomplishments in 2008, "the emergence of more cohesive and cooperative relationships among Centers." *Was it the Panel's assessment that NASA's policy of 10 Healthy Centers is working well? Can you provide examples of such improvement and what NASA is doing to maintain that level of cooperation? Do you have any concerns that need to be addressed?*

A6. It is the panel's opinion that NASA has made substantive, positive progress in the direction of 10 healthy centers. Work being performed by the NESC at Langley for all Centers and better cooperation between Marshall and Johnson are just two examples. The ongoing effort around technical authority is keeping the communication flowing, so the new NASA structure and work processes are helping to promote the "10 Healthy Center Concept."

The panel has raised the question—"Could NASA more efficiently and economically operate with fewer centers?" We appreciate the political and public challenges of rationalizing government facilities; however, fewer, stronger centers could pos-

sibly relieve ongoing funding shortfalls and ease needed improvements to infrastructure.

This said, the ASAP believes there is more work yet to be done on this, particularly in standardizing practices common among the centers, and the ASAP will be looking for continued efforts in this area. One current example is that we are asking for safety data from all centers be reviewed in public at our meetings for leanings that can be leveraged.

Questions submitted by Representative Pete Olson

Q1. During our June 18 hearing, witnesses were in general agreement that converting NASA's spending authority to one-year money would create new hardships for the Agency. Could you elaborate on the consequences of such a change, and perhaps provide an illustrative example?

A1. As noted in the response to Chairwoman Giffords first question, the ASAP does not agree that this proposed change helps NASA, but in fact will cause financial turbulence at a time when stability is required.

Q2. Re-establishing Advanced Technology Development as an independently funded and managed program has been cited as an important reform if NASA is to enhance its capability to develop new and perhaps paradigm-shifting technologies. What caused the Agency to abandon this approach? Was it simply budget; was the return on investment in question? How much annual funding would be required to re-establish a credible program?

A2. The ASAP has no basis to provide counsel on this question as it is outside the panel's focus.

Q3. The International Space Station will, in all likelihood, be utilized by NASA for some years beyond 2015 but at present the Agency appears unwilling to make such a commitment. Our international partner space-agencies have been looking for a firm signal from NASA for such a commitment, as it helps them deal with their governments to lie in long-term funding programs. What's preventing NASA from making such a commitment now?

A3. The ASAP has no basis to provide counsel on this question as it is outside the panel's focus.

Q4. What are your thoughts and concerns about engaging more intensively with international partners to fly joint missions? What are the primary disadvantages against joint international missions, and in your view, would U.S. science research priorities likely be jeopardized if we were to aggressively engage in joint missions? To what degree do export control restrictions make joint missions unwieldy and difficult to manage?

A4. The ASAP has no basis to provide counsel on this question as it is outside the panel's focus.

Q5. Re-invigorating NASA's workforce is especially critical given the average age of the Agency's employees. How would you describe the attractiveness of NASA as a prospective employer, especially from the perspective of a young 'fresh-out'? Would they tend to look at NASA as a career choice? How can NASA best ensure that the knowledge and 'lessons learned' will be passed from the current generation of scientists and engineers to the next?

A5. From all indications, NASA still is successful at attracting co-op students, interns, fresh-outs, and other early-career individuals when vacancies are available. During the past year the Agency has been receiving, on average, over fifty applications for every advertised position; that number has risen to almost 120 during each of the past two months. The ASAP has thus far not heard of indications from hiring managers that sufficiently skilled candidates are missing from those applicant pools. We believe that this stems from several factors, including:

- NASA's unique programs and associated facilities that provide opportunities in aeronautics, science and engineering that are not found (or rarely found) in any other parts of the government—or even the private sector;
- The opportunity to be part of an organization that has a focus on the future, as well as contributing to improving the quality of life on our planet right now;
- Working in an agency recognized across the government as an employer-of-choice (as demonstrated in successive Federal Human Capital Surveys), with

particular focus on recognizing and rewarding talent and establishing an excellent work-life balance; and, more recently,

- The security of government service during an uncertain economic period.

That said, the ASAP believes there are several factors at work that potentially discourage qualified candidates from seeking NASA positions, including: relatively few positions are available given constrained civil servant ceilings and low rates of attrition among the current workforce; concern about adequate opportunities for meaningful, hands-on work early in their careers (a combination of a relatively small number of new programs and low attrition); and uncertainty over the sustainability of major programs across multiple administrations.

We concur that passing along knowledge to the next generation of NASA employees is a critical concern. There are multiple mechanisms for doing so, and from our observations NASA is taking advantage of many of those. For example, the Agency has taken steps to increase formal and informal mentoring programs throughout the Agency. Although focused primarily on enhancing leadership skills, such programs also serve to pass along technical knowledge. A recent "career pathing" program has also been successful in capturing and documenting the developmental experiences of senior Agency personnel from multiple disciplines in order to guide newer employees along similar (or different) paths. One of the most successful mechanisms, however, is working side-by-side with more experienced personnel, and one of the objectives of the Agency's new Early Career Hiring Initiative is to bring substantial numbers of new employees into the Agency far enough in advance of anticipated retirements so that a period of overlap is available for the more experienced employees to pass along what they know before leaving.

Another NASA activity that focuses on knowledge sharing and lessons learned is the Office of the Chief Engineer's Academy for Program/Project/Engineering Leadership (APPEL) program. APPEL places a great deal of emphasis on lessons-learned and mentoring programs designed to pass knowledge to successive generations of engineers and program/project managers. This is done with two primary training activities: courses and performance enhancement. For example, APPEL has recently added a two-day "Space Systems Development: Lessons Learned" course to the curriculum that reviews numerous NASA case studies involving designing and building space flight hardware.

Q6. Over the last decade, NASA has employed several different financial management schemes that directly affect managers and the manner in which they account for—and control—costs within their programs and missions. How effective, and how transparent, is the current system, especially from the perspective of program and mission managers?

A6. The ASAP has no basis to provide counsel on this question as it is outside the panel's focus.

Q7. You recommend that NASA needs to take a more aggressive role articulating human rating requirements for the COTS (Commercial Orbital Transportation System) program. Could you elaborate? Has NASA not yet developed a set of specific standards for potential commercial providers? Will commercial providers be held to a lesser standard than exists today for Orion/Ares?

A7. No, NASA has not yet developed any specific information for COTS providers for human rating requirements, other than those required while delivering and docking with the ISS during cargo missions. In this regard, the ASAP believes NASA is late in developing these important requirements.

The scope of the COTS project and demonstrations involve the development and operation of an end-to-end space transportation system of services including ground operations and integration, launch, rendezvous, proximity operations, docking or berthing, orbital operations, reentry, and safe disposal or return. For the Phase 1, Technical Development/Demonstration funded Space Act Agreements (SAAs), the objective has focused on the qualification of the launch vehicle for cargo delivery and return, including rendezvous and berthing with the International Space Station (ISS). As part of these demonstrations, NASA's approach has been to review Safety and Mission Assurance products, including the safety and mission assurance plan, hazard analysis, safety assessments, risk assessments, probabilistic risk assessments, software assurance and the human-rating plan, during partner design reviews to assure that safety is build into the design and development process—all for the cargo mission.

With respect to a set of specific NASA standards for the potential commercial providers, at the present time the agreements only impose the applicable ISS visiting vehicle requirements as a condition for using the ISS as an orbital destination and

active test bed. Space Station Safety Review Panel's (SRP) phased safety reviews will address rendezvous, approach, docking, undocking, and separation, and compliance with ISS safety requirements. The SRP's approval will be required before being allowed to rendezvous and berth or dock with the ISS—again for the cargo mission.

Launch and re-entry requirements are imposed by the Federal Aviation Administration's Office of Commercial Space Transportation (FAA/AST), through their licensing of all of the COTS demonstration missions. The FAA/AST licensing and regulatory authority does not extend to orbital operations. FAA/AST has the authority to issue licenses for launch and re-entry operations with humans aboard with the licensee responsible for crew and space flight participants' safety to assure the safety of the public and the protection of property.

The FAA licensing involving human space flight will proceed in a multi-step process, starting with experimental operations handled on a case-by-case basis, thus allowing for the regulation to mature as the industry gains relevant flight experience. As directed by Congress, the FAA's final rule for Human Space Flight Requirements for Crew and Space Flight Participants, which became effective on February 13, 2007 expressly addresses requirements for space flight participants (SFP) (the presumed role of an NASA astronaut) to be one of written consent and oral questioning of the operator so as to achieve some type of "affirmation that the space flight participant understands what he or she is getting into before embarking on a mission." The rule indicates that the operator must inform each SFP in writing about the risks of the launch and reentry vehicle type; the known hazards and risk that could result in death, serious injury, or total or partial loss of physical or mental function; and also that there are unknown hazards. The rule indicates that an operator must inform each SFP that the "United States Government has not certified the launch vehicle and any re-entry vehicle as safe for carrying crew or space flight participant."

Therefore, in order to assure that the level of safety for the NASA astronaut on a COTS vehicle be equivalent to that for a NASA astronaut on a NASA-developed vehicle (which NASA has indicated to the ASAP to be their objective), NASA acknowledges its responsibility to define human rating requirements that are required to certify the COTS vehicle as "human-rated," but thus far NASA has not done so. Because the Phase 1 SAAB include an option for crew transportation demonstrations *pending successful cargo demonstrations and additional funding,* there has been no delineation of the specific human-rating requirements in the SAAB to date.

In addition, in further questioning by the ASAP, NASA had given little thought as to what their approach will be in establishing human rating requirements for the COTS program and how they will accept alternative designs, testing, or concepts of operation, etc. This then provided the rationale for the ASAP to press NASA to take a more aggressive role in articulating human rating requirements for the COTS program early on. As a minimum, the ASAP believes that NASA should begin a dialogue with the funded COTS partners *now* to address this issue. Further impetus for this action has been provided recently by plans to spend economic stimulus package funding for COTS D to provide, among other things, better definition of what it will take to human-rate a vehicle originally built to deliver cargo to the ISS.

The ASAP concern to some extent has been exacerbated further by media reports about the funded COTS partners' and other commercial launch providers' ease or readiness in being able to comply with the NASA human-rating requirements when the ASAP has several recommendations relating to the new standard NPR 8705.2B, Human Rating Requirements for Space Systems, issued May 2008, and our perceived problems associated with its implementation within NASA.

Q8. You recommend that the Office of Personnel Management grant NASA the authority to re-employ retired NASA civil servants without penalty, and you specifically cite Marshall Space Flight Center as compelling case where such a change would be welcomed. Why Marshall, and why not other NASA centers?

A8. The ASAP believes that the ability to re-employ retired NASA civil servants would be of benefit to all NASA Centers in cases where they are experiencing difficulty with recruitment and retention, or meeting an unusual temporary hiring need.

Marshall Space Flight Center (MSFC) was used as an example only because of the large numbers of Department of Defense (DOD) components scheduled to move (or that have already moved) to the Huntsville area as a result of recent Base Realignment and Closure (BRAC) activities. The DOD currently enjoys its own specific authority to re-employ federal retirees without penalty; the concern is that this gives them an edge over MSFC when competing for local talent. Additionally, retirement eligible NASA employees can retire and be hired by DOD without losing a significant portion of their retirement pay. This puts centers like Marshall at a dis-

advantage. This is especially troubling during the early stages of a new, major program.

NASA like most other federal agencies has to seek OPM approval to waive the salary offset. Thus far, their experience has been that this is an arduous and time consuming process and puts the Agency at risk of failing to obtain critical personnel on a timely basis.

NASA is using the legislative process to seek NASA-specific authority to reemploy retired NASA civil servants without penalty. If adopted, the legislation would authorize the Administrator to set the pay of re-employed annuitants throughout the Agency without a reduction in their federal salary. Such authority would provide the Administrator the ability to hire annuitants with expertise and corporate knowledge to address short-term critical program needs and mentor the next generation of NASA employees in support of the transition of the Shuttle to Constellation program. If received, such authority would be Agency-wide.

Questions submitted by Representative Dana Rohrabacher

Q1. It is always easy to advocate for more money for NASA. Assuming however, a relatively flat budget, especially for the years following 2010, what guidance can you offer regarding areas in NASA's budget: what areas are of highest priority to you, and what areas are the lowest priorities? What can NASA or Congress do to maximize the science return on its budget? For instance, do you believe it would be prudent to consider closing one or more Centers? If so, which ones? Are there programs that need bolstering? Please offer your best guidance.

A1. The ASAP has no basis to provide counsel on this question as it is outside the panel's focus.

Q2. We're all familiar with the large and growing threat that orbital debris poses to our people and assets in space. This subcommittee recently held a hearing on the topic. AIA recently hosted a briefing on this critical issue. And I think we would all agree that it is critical for us to get working on some form of remediation effort.

a. First—do you all agree on that?

b. Second—is NASA the right agency to head this up?

c. Third—what are the hurdles we need to overcome to create an international effort to get rid of all this debris up there?

d. Fourth—what are the proper roles for commercial entities to play in this?

A2. The ASAP agrees that the space debris issue is a matter of growing concern for all space-faring nations, both in terms of current space operations and future planning exercises. The threat posed by orbital debris to the reliable operation of space systems will continue to grow unless the sources of debris are mitigated. NASA clearly has a role to play in protecting its operations from orbital debris and in not contributing to the orbital debris problem. It is beyond the scope of the ASAP to evaluate the roles and missions that might be assigned to the various federal agencies involved.

Q3. The recent Aerospace Safety Advisory Panel (ASAP) Annual report stated: "From a safety standpoint, the ASAP strongly endorses the NASA position on not extending Shuttle operations beyond successful execution of the December 2008 manifest, completing the ISS." *As you know, this leaves us with a significant gap in our domestic access to space. The ASAP report goes on to say "[we] are not convinced that the Ares I and Orion initial operating capability (IOC) date can be improved appreciably by additional resources." So if we can't extend the Shuttle for safety reasons, and we can't move up the Ares I/Orion date, how could we best spend resources in trying to minimize this gap in space access?*

a. The report also states "There is no evidence that Commercial Orbital Transportation Services (COTS) vehicles will be completed in time to minimize the gap." *Except for the fact that there is inadequate funding to fulfill COTS–D, is there evidence that COTS couldn't be available in time to minimize this space gap? Or reduce it? If NASA were to immediately fund these commercial efforts to modify existing launch vehicles and/or develop new ones, what is the best case scenario for their availability?*

A3. The difficulty of safely and reliably placing humans into earth orbit and returning them is an immense challenge that is not fully appreciated by many. While the future is bright and our hopes are high for the potential of COTS providers, based on the data available to us at this time the ASAP believes that the chances of COTS

being able to advance its own schedule, develop its methodologies, and have successful launches and missions to prove its "space worthiness" in the short time frame before Shuttle shutdown are remote. Further, NASA has not yet provided COTS contractors with the requirements that must be met to enable transport of Government Astronauts.

Q4. There is a renewed focus on NASA looking back at planet Earth, either for climate change research, or weather patterns, or other important roles. But I have always thought NASA did its best work when it was looking outward—when it was a team of true explorers. It's impossible to go over the next hill if you refuse to leave the front porch. Isn't it time that we shifted some of these roles over to other agencies more fully so that NASA can focus on looking out, rather than looking in?

A4. The ASAP has no basis to provide counsel on this question as it is outside the panel's focus.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Kenneth M. Ford, Chairman, National Aeronautics and Space Administration Advisory Council (NAC)

Questions submitted by Chairwoman Gabrielle Giffords

Q1. At the hearing, in response to a question regarding either staying on a two-year accounting scheme or converting to a one-year account as is being proposed by the House Appropriations Committee, you indicated that it was a very bad idea to change to a one-year account. Please elaborate on why you believe this is such a bad idea.

A1. NASA is predominately a research and development (R&D) organization. Due to the duration and complexity of R&D programs, virtually all federal R&D is subject to a two-year period of availability. It is hard to understand why NASA should be different and enjoy less flexibility than other R&D agencies given that its programs are among the most challenging tasks assigned to any federal agency.

If aimed at correcting perceived shortfalls in obligation performance, the House Appropriations Committee proposal would not rectify any shortfalls in NASA budget planning or execution. As Mr. Robert Hanisee, Chairman of the Audit & Finance Committee of the NASA Advisory Council, stressed in his testimony—NASA has greatly improved its financial performance. In FY 2008, NASA obligated 98 percent of its funds in their first year of availability and is on track for similar performance in FY 2009. As noted here and elsewhere, NASA does an excellent job in obligating its funding within the first 12 months of the period of availability. However, the nature of NASA's programs (including the development of unique and extremely complex systems) requires flexibility and funding stability. For example, by late summer in 2006, NASA had committed to Lockheed to build the Orion crew exploration vehicle. NASA had two-year money from '05 and was able to use that money to put Orion on contract, once definitized. If NASA had been restricted to one-year money, the '05 appropriation would have vanished, and more would have been necessary in '06. It is important to appreciate that reducing NASA's already limited flexibility will have no positive effects and will in fact reduce its ability to effectively manage its programs.

The House Appropriations recommendation to allow 10 percent of NASA's R&D appropriations to have two-year availability, on an ad hoc basis, would create an exceptional level of complexity and only increase costs. As with other federal R&D agencies, the longstanding policy of two-year R&D appropriations for NASA should be continued.

Q2. NASA now estimates that Shuttle transition and retirement costs will total about $400 million, a far cry from the $2–$3 billion initially projected. How much confidence do you have in NASA's new estimate?

A2. Although the NAC has not reviewed this issue, I would have more confidence in the current projections of Shuttle transition and retirement (T&R) costs than in previous preliminary estimates, as they represent a higher fidelity assessment of the T&R process than did the earlier estimates.

Q3. Following its February 2009 meeting, the NAC recommended that NASA "Communicate lessons learned on large mission cost drivers to the Science Committee and to decadal survey committees." Could you elaborate on why the NAC made this recommendation? What is your reaction to NASA's efforts to manage cost growth through the use of independent cost estimates and budgeting at a 70 percent confidence level?

A3. The NAC is concerned by cost growth in NASA's large missions and believes that this issue should be examined at all stages of a project's life cycle, starting with a mission's inclusion in one of the National Research Council's (NRC's) decadal surveys. In the past, the estimated costs for missions referenced in past decadal surveys have often turned out to be unrealistically low.

NASA has conducted a number of internal studies and has commissioned outside groups (including the NRC) to do independent analyses of cost growth in large programs. The NAC believes that the consolidated results of these studies should be shared with the NAC members, as well as the decadal survey committees convened by the NRC, to ensure the proper dissemination of the lessons learned.

The decadal survey committees need this information to better inform their future reports (two of which are now underway—Planetary Science, Astronomy & Astrophysics—and a third on Heliophysics should start next year) and to ensure that

their cost estimates for future missions are as realistic as possible. The NAC's Science Committee needs this information to better inform its recommendations to NASA on how to deal with cost growth to date and how to reduce cost growth on future missions.

NASA has made a number of relatively recent changes in its cost estimation and cost containment activities. Budgeting at the 70 percent confidence level makes sense, and the NAC endorses this change; however, these reforms need time to work, and it will be a number of years before we can fully assess the impact of these recent changes on NASA's cost performance.

At our most recent NAC meeting, we were presented with a detailed history and potentially important lessons learned from the Planetary Science Division on the Mars Science Laboratory (MSL) program. This presentation is being converted into a white paper that will be publicly available in the next few months.

Q4. The NAC makes formal recommendations to the NASA Administrator based on its evaluations of the Agency's activities and operations. How satisfied are you with NASA's responsiveness to and implementation of the NAC's recommendations?

A4. We on the NAC are generally very satisfied with NASA's responsiveness to our recommendations. In most cases, NASA concurs with the recommendations and acts on them. In the instances where they have not concurred, a thoughtful explanation has been provided. I have served on several other FACA advisory committees, and I can say with confidence that NASA has been the most responsive agency that I have had the pleasure to serve.

Q5. From your perspective, what are the pros and cons of NASA's 10 Healthy Centers policy? What changes, if any, are needed in that policy? What would improve the interactions among NASA centers?

A5. It is my sense that this policy is generally a good one and has had more positive impacts than negative. It is a useful step toward NASA acting more like a single agency. In recent times, NASA has consistently had more facilities than budget to support them. Another way to say this is that the Agency is "over-facilitized" but not over-staffed. In the past, financially stronger centers were not required to place work, whenever possible, at those centers with unfunded civil servants. As result, in 2005 more than 2,500 FTE-equivalents were charging to overhead, while at the same time JSC, KSC, and MSFC were clamoring for people. Requiring program managers at strong centers to "call NASA" first, before hiring support contracts, essentially solved this problem. By 2008, NASA had only 300 FTE on overhead. Requiring program managers to place work outside their host center also brings in an enormously healthy diversity of views and affords the programs access to the best relevant talent no matter where it is located.

Another advantage of this policy is that it utilizes, supports, and reaffirms the matrix management structure, wherein the chain of command for program work and the chain of command for institutional work and technical authority are different. When "lead centers" did everything internally, the Center Director often thought, with some justification, that he was the "Program Manager-in-Chief" of all programs at that center. With program managers not only allowed but required to place work where it can best be done, individual Center Directors are not under the impression that they are "in charge" of programs, and technical authority is maintained separate from programmatic authority. When program managers of large programs are required to work across the Agency, more decisions are made on a "what's good for the program" or "what's good for the Agency" basis, rather than "what's good for my center." Of course, another approach to alleviating the center centric perspective is to locate the top-level program management of the largest programs at Headquarters rather than at specific field centers.

Although the "ten healthy centers" policy is sound and sensible, there have reportedly (and not surprisingly) been difficulties in its execution. Current implementation of "10 healthy centers" has divided the field centers into two major classes: the large operations centers which receive the lion's share of program leadership (and resources), while the smaller centers (mostly the research centers) are relegated to a lesser status scrambling to compete for work apportioned by the large centers with the resources. The research centers are at risk of becoming, at least partially, job shops for the large centers. This arrangement can cause a situation where a less financially healthy center must place otherwise uncovered people on projects to which they are at best marginally suited. Program managers also sometimes feel they are not getting the best product for their money under these circumstances. It is also the case that geographically distributed work is harder to manage: however, this is a relatively minor weakness.

Some centers have embraced the "ten healthy centers policy," some have only tolerated it, and some remain unreconstructed. In my opinion, under the current funding framework, the pros probably outweigh the cons. Perhaps a better approach would be to provide adequate funding to the underfunded research centers . . . or to consider down-sizing some centers to fit the existing funding profile. Stability of funding, mission, and policies are critically important in making the right decisions about staffing and facility needs.

Questions submitted by Representative Pete Olson

Q1. During our June 18 hearing, witnesses were in general agreement that converting NASA's spending authority to one-year money would create new hardships for the Agency. Could you elaborate on the consequences of such a change, and perhaps provide an illustrative example?

A1. NASA is predominately a research and development (R&D) organization. Due to the duration and complexity of R&D programs, virtually all federal R&D is subject to a two-year period of availability. It is hard to understand why NASA should be different and enjoy less flexibility than other R&D agencies given that its programs are among the most challenging tasks assigned to any federal agency.

If aimed at correcting perceived shortfalls in obligation performance, the House Appropriations Committee proposal would not rectify any shortfalls in NASA budget planning or execution. As Mr. Robert Hanisee, Chairman of the Audit & Finance Committee of the NASA Advisory Council, stressed in his testimony—NASA has greatly improved its financial performance. In FY 2008, NASA obligated 98 percent of its funds in their first year of availability, and is on track for similar performance in FY 2009. As noted here and elsewhere, NASA does an excellent job in obligating its funding within the first 12 months of the period of availability. However, the nature of NASA's programs (including the development of unique and extremely complex systems) requires flexibility and funding stability. For example, by late summer in 2006, NASA had committed to Lockheed to build the Orion crew exploration vehicle. NASA had two-year money from '05 and was able to use that money to put Orion on contract, once definitized. If NASA had been restricted to one-year money, the '05 appropriation would have vanished, and more would have been necessary in '06. It is important to appreciate that reducing NASA's already limited flexibility will have no positive effects and will in fact reduce its ability to effectively manage its programs.

The House Appropriations recommendation to allow 10 percent of NASA's R&D appropriations to have two-year availability, on an ad hoc basis, would create an exceptional level of complexity and only increase costs. As with other federal R&D agencies, the longstanding policy of two-year R&D appropriations for NASA should be continued.

Q2. Re-establishing Advanced Technology Development as an independently funded and managed program has been cited as an important reform if NASA is to enhance its capability to develop new and perhaps paradigm-shifting technologies. What caused the Agency to abandon this approach? Was it simply budget: was the return on investment in question? How much annual funding would be required to re-establish a credible program?

A2. NASA has long enjoyed a reputation as a technology innovator whose stressing applications in space and aeronautics have led to an incredible range of broadly useful technologies. Several years ago, the decision was made to divert a large fraction of the Agency's technology investment into the Constellation Program. Unfortunately, technology research programs are easily stopped and terribly hard to restart. Technology research programs often serve as "the bank" or "reserves" to be sacrificed when more visible and near-term objectives are short on funding. Also, in the past some of NASA's technology programs were accused of looking like "sandboxes" not clearly tied to the most critical Agency needs.

A robust and useful technology program at NASA would be dedicated to stimulating innovation and developing new capabilities not tied to existing mission requirements. Currently, for example, NASA's science missions must carry all the technology risk in the program itself. This makes missions such as MSL particularly vulnerable to the uncertainties and risks associated with the development of fundamentally new technology within the mission itself. Additionally, in the human space flight side of the house, the lack of a robust technology program has naturally driven program managers toward relatively conservative designs and limited technology infusion. A much broader technology focus would likely enable game-changing solutions that could open up entirely new opportunities.

In addition to advanced technology programs in the mission directorates, NASA would be well served by the establishment of a more independent technology R&D organization, perhaps modeled loosely after DARPA. It has been estimated that NASA could re-establish a credible technology program with approximately $500M–$800M in additional funding. This level of funding would restore NASA's technology research efforts to rough equivalence with its previous level of effort.

At the July meeting of the NASA Advisory Council, NASA briefed the Council on the activities of its Innovation and Technology Initiative. This internal working group is in the process of conducting an assessment of advanced technology development at NASA and will soon produce a report on this topic. The Council was very pleased by this initiative and will discuss the forthcoming report at our next meeting (October).

Q3. The International Space Station will, in all likelihood, be utilized by NASA for some years beyond 2015 but at present the Agency appears unwilling to make such a commitment. Our international partner space agencies have been looking for a firm signal from NASA for such a commitment, as it helps them deal with their governments to lay in long-term funding programs. What's preventing NASA from making such a commitment now?

A3. NASA is not taking any action that would preclude a decision to extend ISS operations and utilization beyond 2015. The Administration will have to determine whether to continue U.S. participation in the International Space Station (ISS) Program beyond 2015, and that issue is one of those currently being examined by the Review of U.S. Human Space Flight Plans Committee (Augustine Committee). The Augustine Committee is scheduled to report out options to NASA and to the Office of Science and Technology Policy (OSTP) this August. I would anticipate that the Administration's decision would follow soon thereafter, and NASA would then be able to provide the clarity and commitment that its international partners are seeking.

Q4. What are your thoughts and concerns about engaging more intensively with international partners to fly joint missions? What are the primary disadvantages against joint international missions, and in your view, would U.S. science research priorities likely be jeopardized if we were to aggressively engage in joint missions? To what degree do export control restrictions make joint missions unwieldy and difficult to manage?

A4. International cooperation has long played an important role in NASA's exploration and science activities. In spite of the many obvious potential advantages of pursuing joint international missions, there are also some significant disadvantages, including increased management complexity, technical and programmatic risk, and political risk. One particularly notable disadvantage that hinders the pursuit of joint international missions is that various export control restrictions make such international collaborations unnecessarily cumbersome. It has become evident that improvements in export control policies are necessary to ensure that our foreign partners remain interested in working with NASA and our contractors on future joint programs. Any assistance that this committee could give to reduce the barriers to effective collaboration while maintaining the intended goals of export control regulations would greatly enhance the productivity of international partnerships in space exploration and science.

With specific regard to U.S. science priorities, working more closely with international partners offers a mix of advantages and challenges. As noted above, close cooperation with international partners does indeed add complexity to some missions, including difficulties arising from the aforementioned export control regulations. However, the benefits of increased international cooperation, especially in an era of tightened budgets, will likely outweigh the potential disadvantages. NASA's Science Mission Directorate (SMD) is working closely with the European Space Agency (ESA) to forge a new joint Mars architecture that will likely enable more science than either space agency could achieve on its own given available budgets. That potential cooperation is driven by shared science research priorities. This suggests that a joint NASA–ESA Mars architecture incorporating shared access to the scientific data may actually quicken the pace at which our national science priorities in planetary science are achieved. At our most recent meeting (July 2009), the NAC recommended that SMD build on the progress to date and expand its relationship with ESA to include cooperative Earth science missions.

Q5. Re-invigorating NASA's workforce is especially critical given the average age of the Agency's employees. How would you describe the attractiveness of NASA as a prospective employer, especially from the perspective of a young 'fresh-out'?

Would they tend to look at NASA as a career choice? How can NASA best ensure that the knowledge and 'lessons learned' will be passed from the current generation of scientists and engineers to the next?

A5. From all indications, NASA is still successful at attracting co-op students, interns, fresh-outs, and other early-career individuals. Every year the research firm, Universum, ranks the most desirable employers in the world, based on where undergraduate students say they'd most like to work. NASA was ranked as the #1 ideal employer by engineering students. Additionally, NASA was ranked as #2 by Natural Science students, #5 by Information Technology students, and #12 by Liberal Arts students. In my view there is little doubt that NASA is generally considered a desirable place to work. That said, I do hope that NASA will focus on hiring the very best fresh-outs that our great country can produce rather than settling for less.

Passing along knowledge to the next generation of NASA employees is a critical concern. NASA is involved in several efforts specifically aimed at enhancing knowledge management and transfer. The Office of the Chief Engineer's Academy for Program/Project/Engineering Leadership (APPEL) program places a great deal of emphasis on lessons-learned and mentoring programs designed to pass knowledge to successive generations of engineers and program/project managers. For example, APPEL has recently added a two-day "Space Systems Development: Lessons Learned" course to the curriculum that reviews numerous NASA case studies involving designing and building space flight hardware. APPEL is also collaborating with the Lessons Learned organizations at each center to develop similar offerings. APPEL offers several other courses that similarly focus on lessons learned. APPEL also employs numerous former NASA "grey beards" from past projects such as Hubble Space Telescope, Shuttle, and Viking to bring their experience and knowledge to a new generation of managers in order to develop strong program teams. NASA also encourages knowledge transfer through formal and informal mentoring programs.

However, the success of such efforts rests heavily on NASA's ability to hire adequate numbers of new employees of the highest caliber. I understand that NASA is developing a hiring initiative focused on securing the "best and brightest" talent for the future. Although this initiative is still in the early stages, I am confident that the Agency is progressing toward securing the "next generation" of scientists and engineers who will ensure NASA's success in the future. Close attention must be paid to not just the number of new hires but to their quality. If NASA is to inspire the Nation . . . it must be staffed by the best our country has to offer.

Q6. Over the last decade, NASA has employed several different financial management schemes that directly affect managers and the manner in which the account for—and control—costs within their programs and missions. How effective, and how transparent, is the current system, especially from the perspective of program and mission managers?

A6. The NAC Audit & Finance Committee has assessed the many financial systems NASA has employed over recent years, so I defer to Mr. Bob Hanisee's response, as follows: Over the past decade, NASA has implemented many financial control systems; many of these were ineffective. The current suite of controls, which include the Integrated Enterprise Management System (IEMP), the Core Accounting System, the Continuous Monitoring System, the Phasing and Planning System and the Enterprise Value Management System are all working effectively now. There are still issues that come up with these systems, but it is fair to say that they are working effectively . . . and with transparency. We will of course have a better read on their efficacy following the conclusion of the 2009 financial audit. The Audit and Finance Committee believes that the timeliness and accuracy of financial information provided to Program Managers, Center Directors and to the Administrator are much improved which should result in more effective program management.

Questions submitted by Representative Dana Rohrabacher

Q1. It is always easy to advocate for more money for NASA. Assuming, however, a relatively flat budget, especially for the years following 2010, what guidance can you offer regarding areas in NASA's budget: what areas are of highest priority to you, and what areas are the lowest priority? What can NASA or Congress do to maximize the science return on its budget? For instance, do you believe it would be prudent to consider closing one or more centers? If so, which ones? Are there programs that need bolstering? Please offer your best guidance.

A1. In my view, the highest budget priority is to develop a capable and flexible space transportation architecture as quickly as feasible. In particular, the key ele-

ment in the exploration architecture is the development of a heavy lift launch vehicle. I urge Congress to accelerate and prioritize development of this capability as it is the lynchpin to everything we will do in human space flight beyond low-Earth orbit.

Maximizing the science return of NASA's budget requires a number of coordinated steps. First, NASA needs to retain scientific peer review and the National Research Council's decadal surveys as important components of its decision-making processes. The use of scientific peer review and the priority-setting processes of the decadal surveys are crucial to ensuring that the highest priority science remains at the forefront of NASA planning. Second, NASA's science portfolio needs to maintain a balance among small, medium, and large programs. Each class of mission contributes to the advance of science and to the health of America's scientific and technological base in different ways. Maintaining a balance among the size of missions helps to smooth out science opportunities over time and allows the larger scientific community to plan appropriately. Third, NASA needs to continue to involve the larger scientific community in decisions on how to control cost growth. The steps underway to improve the cost estimates associated with the decadal surveys (especially the use of independent cost reviews) and budgeting at the 70 percent confidence level are important first steps. Finally, NASA would benefit from greater stability in its funding, including funding for science. Funding stability from year to year and receiving appropriated funds at the beginning of each fiscal year would reduce the cost of changes to programs and their industrial contracts and the uncertainty of the annual planning and implementation cycle, freeing up more funds earlier for scientific research. Further, it is important that NASA not be shifted to one-year funding—which would be unique amongst U.S. R&D agencies.

The NAC has not reviewed the question of whether it would be prudent to consider closing one or more centers. With respect to programs needing bolstering, I would advocate re-establishing a robust technology research program at NASA.

Q2. We're all familiar with the large and growing threat that orbital debris poses to our people and assets in space. This subcommittee recently held a hearing on the topic. AIA recently hosted a briefing on this critical issue. And I think we would all agree that it is critical for us to get working on some form of remediation effort.

Q2a. First—do you all agree on that?

A2a. I absolutely agree that the space debris issue is a matter of significant concern that will only worsen if nothing is done to address the problem.

Q2b. Second—is NASA the right agency to head this up?

A2b. As I understand it, NASA does not have the authority to head up a space debris removal effort and that the United States Air Force would likely lead any such effort. NASA can provide technical assistance, and the NASA Orbital Debris Program Office has evaluated a wide range of concepts for the removal of orbital debris. Also the Defense Advanced Research Projects Agency (DARPA) is playing an important role in the search for a cost-effective means of removing hazardous orbital debris.

Q2c. Third—what are the hurdles we need to overcome to create an international effort to get rid of all this debris up there?

A2c. Although there are economic and legal hurdles, the primary challenges associated with creating an international debris remediation effort remain technical in nature. That is, a practical and affordable means of removing orbital debris has yet to be identified.

Q2d. Fourth—what are the proper roles for commercial entities to play in this?

A2d. As major operators of orbital space systems, commercial users certainly have a significant stake in development of a method for space debris remediation. I understand that NASA and DARPA are in dialogue with commercial entities as they investigate various means of removing hazardous orbital debris.

Q3. The recent Aerospace Safety Advisory Panel (ASAP) Annual report stated: "From a safety standpoint, the ASAP strongly endorses the NASA position on not extending Shuttle operations beyond successful execution of the December 2008 manifest, completing the ISS." As you know, this leaves us with a significant gap in our domestic access to space. The ASAP report goes on to say "[we] are not convinced that the Ares I and Orion initial operating capability (lOC) date can be improved appreciably by additional resources." So if we can't extend the

Shuttle for safety reasons, and we can't move up the Ares I/Orion date, how could we best spend resources in trying to minimize this gap in space access?

A3. NASA believes that the best way forward is to remain focused on flying out the remaining seven Space Shuttle missions safely, even if the manifest slips and continuing the development of the Orion and Ares I vehicles. Meanwhile, the U.S. Human Space Flight Review Committee is reviewing options to address the gap as part of their broader mandate.

NASA is promoting the commercial space economy by relying on industry to provide cargo resupply services to the International Space Station (ISS) through the two Commercial Resupply Services contracts signed last December. It is important that NASA's industry partners concentrate on developing the technologies and techniques required to deliver uncrewed vehicles to orbit and conduct proximity operations and docking maneuvers with the Station before they move on to developing crew transportation systems. The need for commercial resupply is critical to the continued operation and conduct of research aboard ISS, and lessons learned in the development and operation of the cargo vehicles will help the development of later crewed systems. The approach of demonstrating cargo first and then stepping up to crew transportation is the best way forward. It is also important to note that NASA is planning to codify human space flight vehicle requirements in order to assist in the development of those capabilities.

At this point, there is not any viable option that will eliminate the gap in U.S. crew transportation to space. That said, by providing NASA with adequate funding and allowing it the freedom to manage these projects without extensive external guidance and constraints this gap could be minimized. There will be issues with the technical development, and these issues will need to be worked by the technical experts. Continuing to change plans will only delay the development process.

Q3a. The report also states "There is no evidence that Commercial Orbital Transportation Services (COTS) vehicles will be completed in time to minimize the gap." Except for the fact that there is inadequate funding to fulfill COTS–D, is there evidence that COTS couldn't be available in time to minimize this space gap? Or reduce it? If NASA were to immediately fund these commercial efforts to modify existing launch vehicles and/or develop new ones, what is the best case scenario for their availability?

A3a. As noted in the question, NASA currently does not have funding to initiate crew transportation demonstrations and, therefore, cannot accelerate COTS Capability D, nor is funding currently identified in the FY 2010 budget. Therefore, if NASA was to be directed to conduct a competition for a crew transportation capability, additional funds beyond the President's budget submit would be required to avoid impacts to other critical programs.

Even if funding were to be received in FY 2010, NASA does not believe that providing additional Government funds to the COTS partners—SpaceX and Orbital—would significantly advance the current development plans for either partner prior to their currently negotiated operational dates for commercial cargo transportation of late 2010 and early 2011, respectively. It is important to remember that from the beginning, NASA was only intended to be an investor in these commercial efforts and that the commercial entities were required to provide the remaining funding themselves or through other financing efforts.

Finally, in the event that NASA were to receive substantial new funding or be directed to shift funding from other critical programs to the development of commercial crew transportation, it would likely take vendors from three to four years to develop and qualify a crew transportation system.

Q4. There is a renewed focus on NASA looking back at planet Earth, either for climate change research, or weather patterns, or other important roles. But I have always thought NASA did its best work when it was looking outward—when it was a team of true explorers. It's impossible to go over the next hill if you refuse to leave the front porch. Isn't it time that we shifted some of these roles over to other agencies more fully so that NASA can focus on looking out, rather than looking in?

A4. The NAC believes that NASA's leadership role in Earth science research should be maintained. Since its establishment 50 years ago, NASA has been at the forefront of Earth science research and maintaining that expertise should be a national priority. NASA's Earth science research program should be strengthened, and its cooperation and coordination with other nations, as well as other domestic agencies and departments, should be increased.

A better scientific understanding of the Earth enhances our understanding of the solar system and of extra-solar planets . . . and vice versa. Earth science and space science have important symmetries that argue against moving Earth science research out of NASA. Likewise, NASA should continue its traditional role in the development and initial on-orbit check-out of operational satellites for other agencies.

NASA is working with domestic agencies to transition operational responsibilities where it makes sense. Finding ways to reduce the administrative and budgetary complications will likely increase the number of successful transitions from research to operations.

NASA is the Nation's civil space agency, and recent experience has shown that other agencies requiring the view from space need the expertise of NASA's space systems development centers to achieve their goals.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Robert M. Hanisee, Chairman, Audit and Finance Committee, NASA Advisory Council (NAC)

Questions submitted by Chairwoman Gabrielle Giffords

Q1. What would be the impact of the one-year funding limitation proposed in the House Commerce, Justice, Science, and Related Agencies Appropriations Committee bill for FY 2010 on the ability of NASA to effectively manage its programs within budget?

A1. NASA is predominately a research and development (R&D) organization, and due to the duration and complexity of R&D programs, virtually all federal R&D is subject to a two-year period of availability. It is hard to understand why NASA should be different and enjoy less flexibility than other R&D agencies given that its programs are among the most challenging tasks assigned to any federal agency.

If aimed at correcting perceived shortfalls in obligation performance, the House Appropriations Committee proposal would not rectify any shortfalls in NASA budget planning or execution. As I stressed in my testimony—NASA has greatly improved its financial performance. In FY 2008, NASA obligated 98 percent of its funds in their first year of availability and is on track for similar performance in FY 2009. As noted here and elsewhere, NASA does an excellent job in obligating its funding within the first 12 months of the period of availability. However, the nature of NASA's programs (including the development of unique and extremely complex systems) requires flexibility and funding stability. For example, by late summer of 2006, NASA had committed to Lockheed to build the Orion crew exploration vehicle. NASA had two-year money from '05 and was able to use that money to put Orion on contract, once definitized. If NASA had been restricted to one-year money, the '05 appropriation would have vanished, and more would have been necessary in '06. It is important to appreciate that reducing NASA's already limited flexibility will have no positive effects and will in fact reduce its ability to effectively manage its programs.

As with other federal R&D agencies, the longstanding policy of two-year R&D appropriations for NASA should be continued.

Q2. That same one-year funding limitation provides an allowance of ten percent in each operational account as two-year funding. Is that proposed allowance of ten percent sufficient, based on your knowledge of the Agency's obligation rates and the uncertainty surrounding research?

A2. No, ten percent is not sufficient. The House Appropriations recommendation to allow ten percent of NASA's R&D appropriations to have two-year availability, on an ad hoc basis, would create an exceptional level of complexity and only increase costs. As with other federal R&D agencies, the longstanding policy of two-year R&D appropriations for NASA should be continued.

Q3. Your prepared statement identifies several steps that NASA has taken to address the financial problems that have "plagued the Agency for almost all of this decade." Are there any issues in the FY 2010 budget request and agency plans for the five-year planning horizon that could interfere with NASA's progress on financial management?

A3. I do not see any issues in the FY 2010 budget request or Agency plans for the five-year planning horizon that would interfere with NASA's progress on financial management. That said, however, if budgetary constraints necessitated a significant cutback in finance department personnel, the result would likely have a negative impact on the financial management progress. Aside from such a cutback, the major issues keeping the Agency from obtaining a clean external audit opinion are technical issues having to do with property accounting and Unfunded Environmental Liabilities. We believe that each of these issues will yield to time and efforts already underway.

Q4. While I understand from your testimony that NASA has instituted several software packages to facilitate effective financial management, I am interested in your perspectives on the role the workforce plays in NASA's financial management practices. To what extent has NASA engaged its workforce in facilitating effective financial management through training, awareness, or other measures?

A4. NASA's workforce does play a key role in facilitating effective financial management. Under the direction of the Office of the Chief Financial Officer (OCFO), the

Agency has undertaken a number of training programs for accounting and financial personnel at both Headquarters and at the centers. This included training in the use of the Integrated Enterprise Management System (IEMP), the Core Accounting System, and the Continuous Monitoring Program. Within the Environmental Department, training in the use of the IDEAL software package has been required, and under the guidance of the Office of the Chief Engineer, over 1,600 participants from all NASA Centers have attended 62 NASA-tailored courses on Earned Value Management to improve program/project cost, schedule and performance management.

Q5. The Subcommittee held a hearing in March to examine cost management issues in NASA's acquisitions and programs. To what extent does the financial management system enable effective cost management of NASA programs?

A5. In addition to the regular financial reports provided to the Administrator and to Center and Mission Directors, the Phasing Plan developed by the OCFO provides regular input on costs incurred versus budget for Themes, Centers, Mission Directorates, and Full Cost Elements. The newest tool, which is being deployed by the Office of the Chief Engineer, is the Earned Value Management system which integrates budgeted costs, incurred costs, time, and progress to date on each project. As this system is proliferated throughout the Agency, program cost management should improve.

Q6. In your prepared remarks, you state that "The NASA Shared Services Center (NSSC) is up and running with performance metrics close to or above the goal levels. Unfortunately, NSSC is unlikely to ever achieve the $100 million cost savings that was the original justification for its creation because of persistent low-transaction volumes." Could you elaborate on the purpose of the Shared Services Center and your concerns about low-transaction volumes? What needs to be done to address those concerns?

A6. Concerns about a loss of control as financial and other functions (travel, grants, etc.) were transferred from the various centers to the NASA Shared Service Center (NSSC) at Stennis Space Center, the OCFO decided to stage the transfer of these function over time. The Wave 4 transfers occurred in August of 2008. In early 2009, accounting for grants was transferred in. The original justification for establishment of the NSSC was that, by relieving the centers of most of their high-volume accounting and financial systems to a central location, cost savings could be realized at the centers. Now, having already transferred most of the high-transaction volume functions into the NSSC, there is not enough volume flowing through the center to realize the cost savings originally projected. To address these concerns, NASA will need to find even more high-volume transactions to transfer to Stennis or, alternatively, Stennis will need to offer its transaction processing services to other (non-NASA) agencies of the U.S. Government.

Questions submitted by Representative Pete Olson

Q1. During our June 18 hearing, witnesses were in general agreement that converting NASA's spending authority to one-year money would create new hardships for the Agency. Could you elaborate on the consequences of such a change and perhaps provide an illustrative example?

A1. NASA is predominately a research and development (R&D) organization, and due to the duration and complexity of R&D programs, virtually all federal R&D is subject to a two-year period of availability. It is hard to understand why NASA should be different and enjoy less flexibility than other R&D agencies given that its programs are among the most challenging tasks assigned to any federal agency.

If aimed at correcting perceived shortfalls in obligation performance, the House Appropriations Committee proposal would not rectify any shortfalls in NASA budget planning or execution. As Mr. Robert Hanisee, Chairman of the Audit & Finance Committee of the NASA Advisory Council (NAC or Council), stressed in his testimony—NASA has greatly improved its financial performance. In FY 2008, NASA obligated 98 percent of its funds in their first year of availability, and is on track for similar performance in FY 2009. As noted here and elsewhere, NASA does an excellent job in obligating its funding within the first 12 months of the period of availability. However, the nature of NASA's programs (including the development of unique and extremely complex systems) requires flexibility and funding stability. For example, by late summer in 2006, NASA had committed to Lockheed to build the Orion crew exploration vehicle. NASA had two-year money from '05 and was able to use that money to put Orion on contract, once definitized. If NASA had been

restricted to one-year money, the '05 appropriation would have vanished, and more would have been necessary in '06. It is important to appreciate that reducing NASA's already limited flexibility will have no positive effects and will in fact reduce its ability to effectively manage its programs.

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Mr. Hanisee defers to the expertise and insights of the NAC Chairman, Dr. Kenneth Ford, to provide the responses to questions 2 through 5.

Q2. Re-establishing Advanced Technology Development as an independently funded and managed program has been cited as an important reform if NASA is to enhance its capability to develop new and perhaps paradigm-shifting technologies. What caused the Agency to abandon this approach? Was it simply budget: was the return on investment in question? How much annual funding would be required to re-establish a credible program?

A2. NASA has long enjoyed a reputation as a technology innovator whose stressing applications in space and aeronautics have led to an incredible range of broadly useful technologies. Several years ago, the decision was made to divert a large fraction of the Agency's technology investment into the Constellation Program. Unfortunately, technology research programs are easily stopped and terribly hard to restart. Technology research programs often serve as "the bank" or "reserves" to be sacrificed when more visible and near-term objectives are short on funding. Also, in the past some of NASA's technology programs were accused of looking like "sandboxes" not clearly tied to the most critical Agency needs.

A robust and useful technology program at NASA would be dedicated to stimulating innovation and developing new capabilities not tied to existing mission requirements. Currently, for example, NASA's science missions must carry all the technology risk in the program itself. This makes missions such as MSL particularly vulnerable to the uncertainties and risks associated with the development of fundamentally new technology within the mission itself. Additionally, in the human space flight side of the house, the lack of a robust technology program has naturally driven program managers toward relatively conservative designs and limited technology infusion. A much broader technology focus would likely enable game-changing solutions that could open up entirely new opportunities.

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Q5. Re-invigorating NASA's workforce is especially critical given the average age of the Agency's employees. How would you describe the attractiveness of NASA as a prospective employer, especially from the perspective of a young 'fresh-out'? Would they tend to look at NASA as a career choice? How can NASA best ensure that the knowledge and 'lessons learned' will be passed from the current generation of scientists and engineers to the next?

A5. From all indications, NASA is still successful at attracting co-op students, interns, fresh-outs, and other early-career individuals. Every year the research firm, Universum, ranks the most desirable employers in the world, based on where undergraduate students say they'd most like to work. NASA was ranked as the #1 ideal employer by engineering students. Additionally, NASA was ranked as #2 by Natural Science students, #5 by Information Technology students, and #12 by Liberal Arts students. In my view there is little doubt that NASA is generally considered a desirable place to work. That said, I do hope that NASA will focus on hiring the very best fresh-outs that our great country can produce rather than settling for less.

Passing along knowledge to the next generation of NASA employees is a critical concern. NASA is involved in several efforts specifically aimed at enhancing knowledge management and transfer. The Office of the Chief Engineer's Academy for Program/Project/Engineering Leadership (APPEL) program places a great deal of emphasis on lessons-learned and mentoring programs designed to pass knowledge to successive generations of engineers and program/project managers. For example, APPEL has recently added a two-day "Space Systems Development: Lessons Learned" course to the curriculum that reviews numerous NASA case studies involving designing and building space flight hardware. APPEL is also collaborating with the Lessons Learned organizations at each center to develop similar offerings. APPEL offers several other courses that similarly focus on lessons learned. APPEL also employs numerous former NASA "grey beards" from past projects such as Hubble Space Telescope, Shuttle, and Viking to bring their experience and knowledge to a new generation of managers in order to develop strong program teams. NASA also encourages knowledge transfer through formal and informal mentoring programs.

However, the success of such efforts rests heavily on NASA's ability to hire adequate numbers of new employees of the highest caliber. I understand that NASA is developing a hiring initiative focused on securing the "best and brightest" talent for the future. Although this initiative is still in the early stages, I am confident that the Agency is progressing toward securing the "next generation" of scientists and engineers who will ensure NASA's success in the future. Close attention must be paid to not just the number of new hires but to their quality. If NASA is to inspire the Nation . . . it must be staffed by the best our country has to offer.

Q6. Over the last decade, NASA has employed several different financial management schemes that directly affect managers and the manner in which the account for—and control—costs within their programs and missions. How effective, and how transparent, is the current system, especially from the perspective of program and mission managers?

A6. Over the past decade, NASA has implemented many financial control systems; many of these were ineffective. The current suite of controls, which include the Integrated Enterprise Management System (IEMP), the Core Accounting System, the Continuous Monitoring System, the Phasing and Planning System, and the Enterprise Value Management System are all working effectively now. There are still issues that come up with these systems, but it is fair to say that they are working effectively . . . and with transparency. We will, of course, have a better read on their efficacy following the conclusion of the 2009 financial audit. The NAC Audit and Finance Committee believes that the timeliness and accuracy of financial information provided to Program Managers, Center Directors, and to the Administrator are much improved which should result in more effective program management.

Q7. You state that NASA's environmental liability is estimated to be $943 million. What are the largest sources of this liability, and at $45 million a year, is NASA prudently managing its environmental obligations in the communities in which it operates?

A7. As noted in my testimony, at the end of FY 2008, the total unfunded environmental liability was $943 million. Within this number were 134 different projects at 15 NASA sites. The projects range from $12 thousand to $168 million. The largest of these is the White Sands Test Facility (39% of the total) which will take 50 years to complete. There are two other sites that could take as long as 100 years to complete. The current spend rate on remediation is $45 million per year. The NAC Audit and Finance committee does not have an opinion as to whether this amount is adequate to manage its environmental obligations in the communities in which it operates.

Questions submitted by Representative Dana Rohrabacher

Q1. It is always easy to advocate for more money for NASA. Assuming, however, a relatively flat budget, especially for the years following 2010, what guidance can you offer regarding areas in NASA's budget: what areas are of highest priority to you, and what areas are the lowest priority? What can NASA or Congress do to maximize the science return on its budget? For instance, do you believe it would be prudent to consider closing one or more centers? If so, which ones? Are there programs that need bolstering? Please offer your best guidance.

A1. In my view, the highest budget priority is to develop a capable and flexible space transportation architecture as quickly as feasible. In particular, the key element in the exploration architecture is the development of a heavy lift launch vehicle. I urge Congress to accelerate and prioritize development of this capability as it is the lynchpin to everything we will do in human space flight beyond low-Earth orbit.

Maximizing the science return of NASA's budget requires a number of coordinated steps. First, NASA needs to retain scientific peer review and the National Research Council's decadal surveys as important components of its decision-making processes. The use of scientific peer review and the priority-setting processes of the decadal surveys are crucial to ensuring that the highest priority science remains at the forefront of NASA planning. Second, NASA's science portfolio needs to maintain a balance among small, medium, and large programs. Each class of mission contributes to the advance of science and to the health of American's scientific and technological base in different ways. Maintaining a balance among the size of missions helps to smooth out science opportunities over time and allows the larger scientific community to plan appropriately. Third, NASA needs to continue to involve the larger scientific community in decisions on how to control cost growth. The steps underway

to improve the cost estimates associated with the decadal surveys (especially the use of independent cost reviews) and budgeting at the 70 percent confidence level are important first steps. Finally, NASA would benefit from greater stability in its funding, including funding for science. Funding stability from year to year and receiving appropriated funds at the beginning of each fiscal year would reduce the cost of changes to programs and their industrial contracts and the uncertainty of the annual planning and implementation cycle, freeing up more funds earlier for scientific research. Further, it is important that NASA not be shifted to one-year funding—which would be unique amongst U.S. R&D agencies.

The NAC has not reviewed the question of whether it would be prudent to consider closing one or more centers. With respect to programs needing bolstering, I would advocate re-establishing a robust technology research program at NASA.

Q2. We're all familiar with the large and growing threat that orbital debris poses to our people and assets in space. This subcommittee recently held a hearing on the topic. AIA recently hosted a briefing on this critical issue. And I think we would all agree that it is critical for us to get working on some form of remediation effort.

Q2a. First—do you all agree on that?

A2a. I absolutely agree that the space debris issue is a matter of significant concern that will only worsen if nothing is done to address the problem.

Q2b. Second—is NASA the right agency to head this up?

A2b. As I understand it, NASA does not have the authority to head up a space debris removal effort and that the United States Air Force would likely lead any such effort. NASA can provide technical assistance, and the NASA Orbital Debris Program Office has evaluated a wide range of concepts for the removal of orbital debris. Also the Defense Advanced Research Projects Agency (DARPA) is playing an important role in the search for a cost-effective means of removing hazardous orbital debris.

Q2c. Third—what are the hurdles we need to overcome to create an international effort to get rid of all this debris up there?

A2c. Although there are economic and legal hurdles, the primary challenges associated with creating an international debris remediation effort remain technical in nature. That is, a practical and affordable means of removing orbital debris has yet to be identified.

Q2d. Fourth—what are the proper roles for commercial entities to play in this?

A2d. As major operators of orbital space systems, commercial users certainly have a significant stake in development of a method for space debris remediation. I understand that NASA and DARPA are in dialogue with commercial entities as they investigate various means of removing hazardous orbital debris.

Q3. The recent Aerospace Safety Advisory Panel (ASAP) Annual report stated: "From a safety standpoint, the ASAP strongly endorses the NASA position on not extending Shuttle operations beyond successful execution of the December 2008 manifest, completing the ISS." As you know, this leaves us with a significant gap in our domestic access to space. The ASAP report goes on to say "[we] are not convinced that the Ares I and Orion initial operating capability (IOC) date can be improved appreciably by additional resources." So if we can't extend the Shuttle for safety reasons, and we can't move up the Ares I/Orion date, how could we best spend resources in trying to minimize this gap in space access?

A3. NASA believes that the best way forward is to remain focused on flying out the remaining seven Space Shuttle missions safely, even if the manifest slips—and continuing the development of the NASA is promoting the commercial space economy by relying on industry to provide cargo resupply services to the International Space Station (ISS) through the two Commercial Resupply Services contracts signed last December. It is important that NASA's industry partners concentrate on developing the technologies and techniques required to deliver uncrewed vehicles to orbit and conduct proximity operations and docking maneuvers with the Station before they move on to developing crew transportation systems. The need for commercial resupply is critical to the continued operation and conduct of research aboard ISS, and lessons learned in the development and operation of the cargo vehicles will help the development of later crewed systems. The approach of demonstrating cargo first and then stepping up to crew transportation is the best way forward. It is also important

to note that NASA is planning to codify human space flight vehicle requirements in order to assist in the development of those capabilities.

At this point, there is not any viable option that will eliminate the gap in U.S. crew transportation to space. That said, by providing NASA with adequate funding and allowing it the freedom to manage these projects without extensive external guidance and constraints this gap could be minimized. There will be issues with the technical development, and these issues will need to be worked by the technical experts. Continuing to change plans will only delay the development process.

Q3a. The report also states "There is no evidence that Commercial Orbital Transportation Services (COTS) vehicles will be completed in time to minimize the gap." Except for the fact that there is inadequate funding to fulfill COTS–D, is there evidence that COTS couldn't be available in time to minimize this space gap? Or reduce it? If NASA were to immediately fund these commercial efforts to modify existing launch vehicles and/or develop new ones, what is the best case scenario for their availability?

A3a. As noted in the question, NASA currently does not have funding to initiate crew transportation demonstrations and, therefore, cannot accelerate COTS Capability D, nor is funding currently identified in the FY 2010 budget. Therefore, if NASA was to be directed to conduct a competition for a crew transportation capability, additional funds beyond the President's budget submit would be required to avoid impacts to other critical programs.

Even if funding were to be received in FY 2010, NASA does not believe that providing additional government funds to the COTS partners—SpaceX and Orbital—would significantly advance the current development plans for either partner prior to their currently negotiated operational dates for commercial cargo transportation of late 2010 and early 2011, respectively. It is important to remember that from the beginning, NASA was only intended to be an investor in these commercial efforts and that the commercial entities were required to provide the remaining funding themselves or through other financing efforts.

Finally, in the event that NASA were to receive substantial new funding or be directed to shift funding from other critical programs to the development of commercial crew transportation, it would likely take vendors from three to four years to develop and qualify a crew transportation system.

Q4. There is a renewed focus on NASA looking back at planet Earth, either for climate change research, or weather patterns, or other important roles. But I have always thought NASA did its best work when it was looking outward—when it was a team of true explorers. It's impossible to go over the next hill if you refuse to leave the front porch. Isn't it time that we shifted some of these roles over to other agencies more fully so that NASA can focus on looking out, rather than looking in?

A4. The NAC believes that NASA's leadership role in Earth science research should be maintained. Since its establishment 50 years ago, NASA has been at the forefront of Earth science research and maintaining that expertise should be a national priority. NASA's Earth science research program should be strengthened, and its cooperation and coordination with other nations, as well as other domestic agencies and departments, should be increased.

A better scientific understanding of the Earth enhances our understanding of the solar system and of extra-solar planets . . . and vice versa. Earth science and space science have important symmetries that argue against moving Earth science research out of NASA. Likewise, NASA should continue its traditional role in the development and initial on-orbit check-out of operational satellites for other agencies.

NASA is working with domestic agencies to transition operational responsibilities where it makes sense. Finding ways to reduce the administrative and budgetary complications will likely increase the number of successful transitions from research to operations.

NASA is the Nation's civil space agency, and recent experience has shown that other agencies requiring the view from space need the expertise of NASA's space systems development centers to achieve their goals.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Berrien Moore III, Member, National Academies' Space Studies Board (SSB)

Questions submitted by Chairwoman Gabrielle Giffords

Q1. While the Administration has requested increases for NASA in the FY10 budget and Congress has provided additional funding through the Recovery Act, the outyear projections for NASA's budget are essentially flat. What are your biggest concerns about the projected budget for NASA over the next five years?

A1. I share the concerns, which are well understood by this committee, that NASA is being tasked to do too much with too little. The "Review of United States Human Space Flight Plans Committee" (also known as the HSF Committee or the Augustine Commission) concluded that the United States could conduct a "meaningful" human space flight program only by adding at least $3 billion annually to NASA's budget. Our ability to execute the high priority Earth observation programs recommended in the 2007 NRC decadal survey that I co-chaired, "Earth Science and Application from Space," also requires a budget enhancement. The funding needs that the Decadal Study projected were to return the Earth science budget to the dollar equivalent that was available in FY 2000. Unfortunately, this budget growth has not materialized and mission costs have exceeded assumptions. With a flat top line budget and tremendous pressures coming from the human space flight side of the agency, I am greatly concerned about the viability of the Earth observation programs in general and our ability to provide decision-makers with critical data related to the pace, magnitude, and impacts of climate change in particular. In a recent (December 14 2009) issue of *Space News*, I also set forth the important role of space observation in improving climate models.

Q2. Global climate change is one of the major issues facing the Nation and the world, and NASA's Earth observation data and research have contributed significantly to the understanding of climate change. However, there are other nations with Earth observation systems that are also collecting climate change data and information. What is the status of international cooperation on global climate change monitoring? What, if anything, is needed to ensure that effective mechanisms are in place to facilitate international collaboration on global climate research and monitoring?

A2. The Group on Earth Observations is a reasonably effective international coordination mechanism; however, it does not bring "new" money to the table. NASA actively pursues collaborations with other space-faring nations. However, the budgets of many space agencies are under pressure, and as a consequence, there is both a national and an international inadequacy of Earth observing capabilities. The one additional element that I could foresee as making a fundamental difference would be, in effect, a U.S.-led international initiative on climate monitoring and research. In this regards, let me note that in July 2009 the National Research Council released a new report, *"America's Future in Space: Aligning the Civil Space Program with National Needs,"* which set forth six strategic goals for guiding program choices and resource planning for U.S. civil space activities. The first of these is: *"To reestablish leadership for the protection of Earth and its inhabitants through the use of space research and technology."*

Q3. As a Co-Chair of the National Academies' Earth science decadal survey study, what is your perspective on the difference between the decadal survey committee's cost estimate and NASA's current estimate to develop the first two decadal missions—SMAP and ICESat–II?

A3. Absent the resources to contract for rigorous independent cost estimates, the Decadal Survey relied mostly on scientists and engineers at various NASA centers to validate internally-derived estimates, or more typically to provide a NASA-derived cost estimate. For missions that did not have strong traceability to past development, the estimates were understandably very rough; further, cost estimates for these comparatively immature missions were more likely to suffer from overly optimistic views on the technical challenges for implementation. In contrast, we believed our estimates of the cost of SMAP and ICESat–II would be on firmer ground.

SMAP was effectively the reincarnation of Hydros, a mission first proposed in response to NASA's third solicitation for the cost-capped Earth System Science Pathfinder Program (ESSP). Hydros was selected as an alternate ESSP mission in 2002, and selected for mission formulation in December 2003. However, in 2005, as part

of NASA's response to a $3.1 billion shortfall in flight-related programs, Hydros was not funded and the mission was effectively canceled. With an identical instrument suite to Hydros, SMAP cost estimates were thought to be well understood. ICESat–II was envisioned by the survey as effectively a re-flight of the existing ICESat mission; again, the survey team believed it understood its costs very well.

Estimates for the cost of both of these missions have risen dramatically. In February 2007, NASA presented cost estimates for the SMAP mission that were $350–$400 million,[1] which are consistent with the Decadal Survey's estimate of $300 million ± 30 percent (FY 2006 dollars). Estimates for SMAP are reportedly now closer to $700 million. Some of this increase is the result of recent changes in launch vehicle costs, new requirements for NASA to budget missions with higher reserves (so that target costs will not be exceeded to a 70 percent confidence level), and a stretching of the schedule for mission completion.

However, I believe a significant fraction of the cost increase is associated with the mission being executed "in-house" at the NASA Jet Propulsion Laboratory, versus execution in the "Principal-Investigator Mode" envisioned by the Decadal Survey. Executing missions in-house has proven to incur several penalties: 1) it eliminates any competition and cost controlling mechanisms; 2) it eliminates any programmatic view of the importance of the whole rather than of a particular missions, which has lead to increasing the mission requirements of each mission at a penalty to our ability to accomplish the whole, and 3) it eliminates the potential innovation of the university or private sector communities. Finally, in missions executed in-house by NASA are incurring higher costs as a result of supposedly revenue neutral change to "full-cost" accounting. The Decadal Survey missions SMAP, ICESat–II and CLARREO are being developed in-house at NASA's Jet Propulsion Laboratory, Goddard Space Flight Center, and Langley Research Center, respectively.

Estimates for the cost of ICESat–II have also increased dramatically from survey estimates. Some of the increases are the result of the mission being executed in-house at NASA's Goddard Space Flight Center as well as the accounting and budgetary changes noted above. In addition, ICESat–II is now being designed with a longer lifetime (five years vs. the survey's estimate of three years), which has significant impact on the cost of the laser and other components. In addition, the collection optics for ICESat–II are larger than ICESat and the resulting instrument package has had to move to a larger, more expensive launch vehicle.[2]

ICESat–II will also carry a multi-beam laser versus the single beam on ICESat to meet science requirements of annually and seasonally resolved elevation and mass changes, particularly in areas with larger surface slopes or with slopes changing with time.

Finally, I note that the CLARREO mission has experienced a larger percentage growth in cost than either SMAP or ICESat–II. In addition to being executed in-house and being subject to the budgetary and accounting changes already noted, NASA concluded that the baseline mission envisioned by the survey would not meet mission objectives. Changes in the number of spacecraft and instrument capabilities account for a sizable fraction of the increase in CLARREO's estimated costs, which are now some $800 million.

Q3a. What is your reaction to NASA's efforts to manage cost growth through the use of independent cost estimates and budgeting at a 70 percent confidence level?

A3a. I support both approaches; however, I am not certain that they would prevent the problems of "assignment to Centers" (noted above).

Q3b. What are the most critical issues on cost management that this Subcommittee should consider as it prepares to reauthorize NASA?

A3b. Mission cost caps might be of use to control a science requirements generation process that otherwise has a natural tendency to push capabilities beyond what might be analogous to a "sweet spot" in cost versus capabilities. We should recognize that even with improved cost management, the NASA budget is not adequate to support implementation of the Decadal Survey in anything like that envisioned and, more importantly, what is needed. I believe that the "wedge" that is described in the Decadal Study was adequate, but under current cost estimates and performance,

[1] Stephen Volz, Associate Director, Flight Projects, NASA Earth Science Division, "New Mission Concepts for the Future, February 7, 2008. Available at: *http://tinyurl.com/y8sjjsv*

[2] The Decadal Survey assumed availability of Delta–II class launch vehicles for medium-lift needs. It should also be noted that the Delta–II line, first introduced some 20 years ago, is being discontinued. Until replacements are developed (Falcon 9 and Taurus 2), missions requiring only medium-class launchers may be forced to use more expensive, larger-class launch vehicles.

this wedge (even though aggressive) falls far short of being adequate to meet current and future NASA costs for vitally-needed Earth observing missions.

Q4. The Orbiting Carbon Observatory (OCO) satellite was unfortunately lost in a launch failure earlier this year. NASA's budget request does not include funds for a replacement satellite yet NASA has indicated that it is looking at options for re-flying OCO or a similar sensor. How important is an OCO-like satellite for climate change research and for verification and validation of potential climate policies and/or agreements?

A4. I begin by noting that the specific measurements needed to support a treaty monitoring/verification regime, or notional market-based carbon dioxide (CO_2) trading schemes, will vary according to the specific mechanism proposed (e.g., sectors covered, time scale for compliance, size of projects/sources considered). Most proposed mechanisms require knowledge of how much is being emitted and by whom (i.e., magnitude and attribution). Some require knowledge of where the carbon is going or where it is stored (e.g., offset mechanisms). The degree of acceptable uncertainty in any of these factors will determine which specific measurements are needed.

A National Research Council committee is conducting a study on how well greenhouse gas emissions can be measured for treaty monitoring and verification. The committee's initial analysis suggested that NASA's Orbiting Carbon Observatory (OCO), which failed on launch in February 2009, would have provided proof of concept for space-borne technologies to monitor greenhouse gas emissions, as well as some baseline emissions data. However, it is important to recognize that OCO was designed to meet science requirements that called for the capability to measure atmospheric carbon dioxide with the precision, resolution, and coverage needed to characterize regional scale CO_2 sources and sinks and quantify their variability over the seasonal cycle. The orbital path, viewing geometry, and observing strategy that results from consideration of these requirements is less than ideal from that desired for treaty monitoring and verification. It is especially important to recognize that the instrument on OCO that detects CO_2 makes measurements using reflected sunlight (more precisely, an instrument on OCO detects changes in reflected sunlight in known near-infrared absorption bands of CO_2); therefore, OCO can only operate in the daytime. Further, in the wintertime at high latitudes, there is too little sunlight to make these measurements.

Nevertheless, as clearly explained in a letter report on OCO dated July 28, 2009 (*http://www.nap.edu/openbook.php?record_id=12723&page=1*), the currently deployed suite of ground and space-based sensors—both U.S. and foreign—are not adequate for monitoring of prospective treaties. A re-flight of OCO is also advantageous as it could occur relatively quickly and at lower cost compared to alternatives.

For the issues of verification and validation of potential climate policies and/or agreements, we will eventually need a separate carbon monitoring system that employs multiple platforms deployed on the ground, from aircraft, over the oceans, and in space. The ASCENDS mission that was recommended in the Decadal Study could play an important role in the space-based component of an overall system. ASCENDS would use an active sensor (lidar), which would allow measurements at night and at very high latitudes, where reflected sunlight techniques cannot make observations. (Over areas with reflected sunlight, passive techniques are currently more precise and have higher down-track spatial resolution.)

Q4a. What is the impact to the overall Earth science program if NASA launches an OCO-like replacement without receiving additional funds?

A4a. It will simply be a tax on an inadequate budget, and therefore will result in further delay of the missions in the Decadal Study queue. It is important to note that NASA's Earth Science programs are already being impacted by a large unfunded mandate of some $140 million to incorporate a thermal infrared sensor on the Landsat Data Continuity Mission.

Q5. You have been involved, in some way, in science and engineering education and with developing the workforce of America's space program. What are your thoughts on the most critical issues and priorities that NASA should address as part of its educational activities and workforce programs going forward? What, if anything, in NASA's education programs and portfolio would you change, and why?

A5. NASA should become a focal point for creativity and innovation. It must become again an agent that embraces and accelerates change. It has lost touch with young people because it is seen as being backward focused (going back to the Moon is hardly a step-forward).

I would expand significantly the educational programs and responsibilities within the science and exploration lines and not leave education to an Education Office. This said, there must be accountability for these educational programs within the exploration and science lines and these programs must not be allowed to be "slush funds" to use against cost overruns.

Q6. What, in your view, should be the criteria for determining whether technology, instruments, or other project activities should be developed at NASA Centers or externally through competitive bidding? What, if anything, does Congress need to consider regarding the balance and diversity of institutions supporting NASA's programs?

A6. The primary criterion for any activity for a NASA Center is the issue of national capability vs. industrial and/or university capabilities. NASA should be doing tasks that are primarily tasks that no university or industry (or collections thereof) can do.

Regarding the balance and diversity of institutions supporting NASA programs: There are many aspects to this question, but a key issue is finding the appropriate balance between programs executed inside or outside of the NASA Centers. As I noted in my response to Question 3, above, executing missions in-house has proven to incur several penalties; I believe competition from industry and university-based researchers is both fiscally responsible and desirable from a scientific perspective.

Questions submitted by Representative Pete Olson

Q1. During our June 18 hearing, witnesses were in general agreement that converting NASA's spending authority to one-year money would create new hardships for the agency. Could you elaborate on the consequences of such a change, and perhaps provide an illustrative example?

A1. Most of NASA's research and development activities are inherently multi-year. To force-fit annual commitments on what is fundamentally multi-year will only lead to ineffective (or worse) actions. By way of examples: Consider the very simple task of granting a fellowship for graduate education, or the complicated contractual efforts to build a Shuttle replacement, and assume that you can only make a commitment (even if monies are available) for one year. Clearly, such an arrangement would be cumbersome at best.

Q2. Re-establishing Advanced Technology Development as an independently funded and managed program has been cited as an important reform if NASA is to enhance its capability to develop new and perhaps paradigm-shifting technologies. What caused the agency to abandon this approach? Was it simply budget; was the return on investment in question? How much annual funding would be required to re-establish a credible program?

A2. Although my knowledge of this area is limited, it should be noted that the Space Studies Board recently completed a report, *"Fostering Visions for the Future: A Review of the NASA Institute for Advanced Concepts,"* that addresses aspects of these questions. The report is available from the Board, or it can be download at: *http://www.nap.edu/catalog.php?record_id=12702*

Q3. The International Space Station will, in all likelihood, be utilized by NASA for some years beyond 2015 but at present the agency appears unwilling to make such a commitment. Our international partner space agencies have been looking for a firm signal from NASA for such a commitment, as it helps them deal with their governments to lay in long-term funding programs. What's preventing NASA from making such a commitment now?

A3. My assumption is that NASA is still "digesting" the report from the Augustine Commission, but clearly this digestion needs to be accomplished soon.

Q4. What are your thoughts and concerns about engaging more intensively with international partners to fly joint missions? What are the primary disadvantages against joint international missions, and in your view, would U.S. science research priorities likely be jeopardized if we were to aggressively engage in joint missions? To what degree do export control restrictions make joint missions unwieldy and difficult to manage?

A4. I am a strong supporter of international collaboration as a way to leverage scarce resources and to advance non-scientific national objectives. The obvious disadvantages of working with international partners include the additional complexity of mission management and an increased vulnerability to "failure" should one of the

partners fail to provide promised resources. It should be noted, however, that in the past we have found our partners to be highly reliable. Collaboration also ensures that often knotty problems related to data availability and compatibility are worked out in advance.

The U.S. Government mechanism for controlling dual-use items—items in commerce that have potential military use—is the Export Administration Regulations (EAR) administered by the Department of Commerce; items defined in law as defense articles fall under the jurisdiction of the Department of State and the International Traffic in Arms Regulations (ITAR). Because of the potential military implications of the export of defense articles, the ITAR regime imposes much greater burdens (on both the applicant and the government) than does the EAR regime during the process of applying for, and implementing the provisions of, licenses and technical assistance agreements.

Until the early 1990s export control activity related to all space satellites (commercial and scientific) was handled under ITAR. Between 1992 and 1996 the George H.W. Bush and the Clinton Administrations transferred jurisdiction over the licensing of civilian communications satellites to the Commerce Department under EAR. In 1999, however, in response to broad concerns about Chinese attempts to acquire U.S. high technology, the U.S. House of Representatives convened the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China, also known as the Cox Committee.

One of the many consequences of the Cox Committee's report was Congress's mandate that jurisdiction over export and licensing of satellites and related equipment and services, irrespective of military utility, be transferred from the Department of Commerce to the State Department and that such equipment and services be covered as defense articles under ITAR. Scientific satellites were explicitly included despite their use for decades in peaceful internationally conducted cooperative scientific research. It is widely recognized that the shift in regulatory regime from EAR to ITAR has had major deleterious effects on international scientific research activities that depend on satellites, space flight hardware, and other items that are now controlled by ITAR. Furthermore, contravening U.S. interests in attracting foreign students to U.S. universities, the capture of space technology by ITAR has caused serious problems in the teaching of university space science and engineering classes, virtually all of which include non-U.S. students.

Q5. Reinvigorating NASA's workforce is especially critical given the average age of the Agency's employees. How would you describe the attractiveness of NASA as a prospective employer, especially from the perspective of a young 'fresh-out'? Would they tend to look at NASA as a career choice? How can NASA best ensure that the knowledge and 'lessons learned' will be passed from the current generation of scientists and engineers to the next?

A5. I find NASA to still be an exciting and inviting place to work and its post-Apollo achievements from the Hubble Space Telescope to planetary probes to the Earth Observing System demonstrate that the Agency is more than capable of carrying out world-class and transformative research. Regrettably, NASA is now being asked to do "too much with too little" and its capabilities across the board are suffering. Regarding specific workforce issues, I recommend to the Committee the recent Space Studies Board report, *"Building a Better NASA Workforce: Meeting the Workforce Needs for the National Vision for Space Exploration"* (available at: *http://books.nap.edu/catalog.php?record_id=11916*). Although this report focuses on the needs of the human space flight program, much of its discussion to the broader questions that are posed above.

Q6. Over the last decade, NASA has employed several different financial management schemes that directly affect managers and the manner in which the account for—and control—costs within their programs and missions. How effective, and how transparent, is the current system, especially from the perspective of program and mission managers?

A6. In my view, the current system (including "full cost accounting") is neither effective or transparent, but I am not a "program and mission manager."

Questions submitted by Representative Dana Rohrabacher

Q1. It is always easy to advocate for more money for NASA. Assuming however, a relatively flat budget, especially for the years following 2010, what guidance can you offer regarding areas in NASA's budget, what areas are of highest priority to you, and what areas are the lowest priority? What can NASA or Congress do to maximize the science return on its budget? For instance, do you believe it

would be prudent to consider closing one or more Centers? If so, which ones? Are there programs that need bolstering? Please offer your best guidance.

A1. I believe that NASA's highest priorities are in the areas of Earth observations and the support of science and exploration. In order to rank the lowest priorities, I would need additional information regarding the parts of NASA with which I am less familiar.

To maximize our science return, we must begin by increasing our ability to control costs—this will free up precious dollars that are required to support research and analysis programs.

Closing Centers: The previous NASA Administrator committed the agency to a strategy to maintain, "10 healthy centers." I believe the consolidation of one or more NASA Centers could be accomplished without a deleterious impact on NASA's core capabilities.

Which one? I would recommend that the Committee consider an approach similar to that adopted by DOD (the Brac Commission: (*http://www.brac.gov/*).

What programs need bolstering? My view is well know: The Decadal Survey, Earth Science and Applications from Space, presented an integrated program to advance Earth system science and deliver information and data products of vital importance to the health of our nation. Especially as we confront a multitude of rapidly changing environmental forces, there can be no higher priority within NASA than robust support for these programs.

Q2. Cost growth in missions, especially flagship, is seriously challenging the Agency's ability to sustain a broad portfolio of science missions. No matter recent efforts to use more realistic estimates, there continues to be evidence that the phenomenon exists today among missions now going through the earliest stages of pre-formulation planning. What is the largest source of cost growth, and going forward, what structural changes would you recommend to guard against exorbitant, unanticipated increases?

A2. I do not know the largest "source of cost growth," but among the problems are: a) maintaining the size of the Agency and full cost accounting, b) selling missions at a low cost when the reality is otherwise, and c) using (and being forced to use) an inefficient cost profile; for example, by stretching out missions as they encounter funding or technical delays.

A National Research Council study, "Cost Growth in NASA Earth and Space Science Missions," is nearing completion. This study is charged with identifying the primary causes of cost growth in NASA Earth and space science missions involving large, medium, and small spacecraft. The study will also recommend what changes, if any, should be made to contain costs and ensure frequent mission opportunities in NASA's Earth and space science programs. In particular, the committee was asked to:

- Review existing cost growth studies related to NASA space and Earth science missions and identify their key causes of cost growth and strategies for mitigating cost growth.
- Assess whether those key causes remain applicable in the current environment and identify any new major causes.
- Evaluate the effectiveness of current and planned NASA cost growth mitigation strategies and, as appropriate, recommend new strategies to ensure frequent mission opportunities.

Q3. We're all familiar with the large and growing threat that orbital debris poses to our people and assets in space. This subcommittee recently held a hearing on the topic. AIA recently hosted a briefing on this critical issue. And I think we would all agree that it is critical for us to get working on some form of remediation effort.

a. First—do you all agree on that?

b. Second—is NASA the right agency to head this up?

c. Third—what are the hurdles we need to overcome to create an international effort to get rid of all this debris up there?

d. Fourth—what are the proper roles for commercial entities to play in this?

A3. The problem of orbital debris is indeed one that is growing in importance. I am not sufficiently expert to usefully comment on the questions raised here. I do note that a number of authoritative reports on the technical issues are available (including a 1995 report from the NRC: *http://www.nap.edu/catalog.php?record_id=4765*).

Q4. The recent Aerospace Safety Advisory Panel (ASAP) Annual report stated: "From a safety standpoint, the ASAP strongly endorses the NASA position on not extending Shuttle operations beyond successful execution of the December 2008 manifest, completing the ISS." As you know, this leaves us with a significant gap in our domestic access to space. The ASAP report goes on to say "[we] are not convinced that the Ares I and Orion initial operating capability (IOC) date can be improved appreciably by additional resources." So if we can't extend the Shuttle for safety reasons, and we can't move up the Ares I/Orion date, how could we best spend resources in trying to minimize this gap in space access?

a. (Follow-up): The report also states "There is no evidence that Commercial Orbital Transportation Services (COTS) vehicles will be completed in time to minimize the gap." Except for the fact that there is inadequate funding to fulfill COTS–D, is there evidence that COTS couldn't be available in time to minimize this space gap? Or reduce it? If NASA were to immediately fund these commercial efforts to modify existing launch vehicles and/or develop new ones, what is the best case scenario for their availability?

A4. I do not believe that I can offer any advice that is better than what the Augustine Commission provided.

Q5. There is a renewed focus on NASA looking back at planet Earth, either for climate change research, or weather patterns, or other important roles. But I have always thought NASA did its best work when it was looking outward—when it was a team of true explorers. It's impossible to go over the next hill if you refuse to leave the front porch. Isn't it time that we shifted some of these roles over to other agencies more fully so that NASA can focus on looking out, rather than looking in?

A5. "Looking back" at planet Earth is one of the best ways to look forward into the nature of tomorrow's climate, which will have profound implications that range from the availability of fresh water in the western regions of the United States to the agricultural productivity of the Midwest to the vulnerability of our coastal regions to sea-level rise and potentially more intense severe weather events. Indeed, the entire U.S. economy and our national security will be affected by changes in global climate. The question of whether NASA is engaged in activities that are better suited to other agencies is embedded in a larger problem: The Nation lacks a coherent strategy for Earth observations that provides for operational climate monitoring and prediction, scientific advances, and the continuation of long-term measurements.

ANSWERS TO POST-HEARING QUESTIONS

Responses by J.P. Stevens, Vice President for Space Systems, Aerospace Industries Association (AIA)

Questions submitted by Chairwoman Gabrielle Giffords

Q1. While the Administration has requested increases for NASA in the FY10 budget and Congress has provided additional funding through the Recovery Act, the out year projections for NASA's budget are essentially flat. What are your biggest concerns about the projected budget for NASA over the next five years?

A1. Inadequate funding could lead to the postponement of projects in the Constellation Program and other programs which would harm our aerospace workforce. Our civil and contractor space Shuttle workforce has unique skills and history at NASA that will be valuable to later projects. If they cannot transition to new projects as the Shuttle retires, we are in danger of losing those workers to other jobs outside of the space community from which they may not return.

A second concern is the need for additional funding to operate the International Space Station through 2020. (In April the CBO projected these costs at $1.4B annually.) These funds should be in addition to current funding projections so ISS operation does not impact other NASA projects.

Q2. Now that the ISS is nearly complete, there is ongoing dialogue about the need to fully utilize the ISS laboratory. What is the significance of the ISS for NASA's future research and exploration activities and for society? What is needed, and when, to make full use of the ISS asset? Aside from the results of the Augustine committee's review, what are the decisions that will determine the extent and longevity of ISS utilization?

A2. The ISS is the only system in place to study long-term effects on humans in space. It also is a good model or test bed for understanding the demands of critical systems crew will need for longer journeys beyond low-Earth orbit.

For full use of the ISS there will need to be appropriate transportation to take equipment up to the ISS and to return samples to Earth. There are several options for delivery to the ISS during the gap, such as Soyuz, Progress, ATV, HTV, and Commercial Resupply Services (CRS). However, the only solutions for down-mass needs are Soyuz—which has very limited space—and a CRS system capable of reentry that is currently under development.

Furthermore, as mentioned above, the ISS will need funding to operate through 2020. These funds should be in addition to current NASA funding projections so ISS operation does not impact other NASA projects.

Q3. The AIA report, "The Role of Space in Addressing America's National Priorities," *recommends that* "The Administration should establish, fund, and implement a U.S. Earth Observation architecture as a national priority." *Has AIA given any guidance on what such an architecture should look like. What questions need to be asked and what decisions need to be made in planning an Earth Observation architecture?*

A3. The U.S. needs a robust Earth Observation capability to sustain our collection of critical global data. Currently, there is no overarching architecture to serve as the basis for research, development, applications and integration plans. A national long-range architecture is needed to guide plans that cross federal agency boundaries and leverage the contributions of academia and industry for effectively collecting and managing this important information.

The national Earth Observation systems architecture should be developed with input provided by experts from government, academia, industry, and the private sector and should reflect the interests and needs of the supply and demand sides of the market architectural blueprint should take a long view, with horizons out for at least two generations, as well as provide guidance in transitioning new technology research sensors and systems into the next generation of operational observing systems.

The Office of Science & Technology Policy (OSTP) is currently working on a policy related to this subject (United States Group on Earth Observations policy). AIA supplied approximately 25 pages of input to the OSTP which can be accessed at: *http://www.aia-aerospace.org/industry_information/reports_white_papers/*.

Q4. The AIA and its members have been active in science and engineering education and with developing the workforce of America's space program. What are your thoughts on the most critical issues and priorities that NASA should address

as part of its educational activities and workforce programs going forward? What, if anything, in NASA's educational programs and portfolio would you change, and why?

A4. AIA is a strong supporter of NASA's education efforts and looks to NASA in a spirit of collaboration to help address critical issues that we share: an aging workforce and a sparse selection of domestic students who are well-prepared and interested in science and engineering careers, particularly in the aerospace sector.

Three suggestions AIA would contribute to NASA's K–12 education program and portfolio are: 1) make career "pathways" more obvious to young people, including the involvement of school counselors and on-line social networking; 2) formal involvement and collaboration with local school districts/communities where NASA facilities are present; and 3) place more emphasis on teacher development. All three of these suggestions aim to make a "larger impact."

1) NASA's overall education framework very thoughtfully organizes its education programs into four categories: inspire, engage, educate, and employ, with each category referring to a different point in the "pipeline" (i.e., informal education, elementary and secondary education and higher education, respectively). However, the programs themselves are not executed in a way that is holistic. For example, a young person may participate in a NASA program in eighth grade, but when she gets to high school that support may not longer be there resulting in: a) the student losing interest or b) the student not having the right support for her career path. Thus suggestion one aims to have these support systems in place for young people at each stage of their educational journey. A further evolution of this suggestion is for NASA to develop a system where there is a NASA educational component throughout a young person's education from K through post-secondary.

2) Since education happens at the local level, each NASA education office should have strong relationships with their school districts, local industry and other stakeholders. Throughout the nation such "innovation networks" are already taking place and having an 'Education Community Liaison' at each center would take existing partnerships and elevate them to a level where centers aren't just doing a field trip here, or a classroom program there, but are really part of the local dialogue with the goal of using their very finite government resources as effectively as possible.

3) Research points to well-trained teachers as the single most important factor in a student's success in STEM. We support and stress that NASA emphasize efforts on professional development for current and aspiring teachers.

For post-secondary education (two- and four-year institutions) AIA suggests: 1) increase money/in-kind support for hands-on/R&D projects for students and teachers, 2) develop cohort programs that make career paths obvious and include pathways into federal service or into private industry. Both of these suggestions aim to develop young people who have actual work experience and have the propensity for a career in aerospace.

Q5. The AIA's report, "Launch into Aerospace: Industry's Response to the Workforce Challenge," *discussed the goal of pursuing* "legislative incentives to encourage skilled retirees to become STEM teachers." *Could you elaborate on what legislative approach the AIA believes would be effective?*

A5. As we face the need for over 200,000 STEM teachers within the next decade, employing the skills of our nation's retiring STEM workforce is obvious and logical.

A major barrier for an individual to work as a teacher after retirement is the penalty on their retirement benefits. Consequently, legislation that would reduce the burden on retirees who elect to go back as science and math teachers should be explored. Right now, social security benefits are such that if a retiree goes back to work as a teacher, they may no longer receive retirement benefits because of their teaching income.

One suggestion is a federal program that would not penalize retirees who become math and science teachers, similar to a loan forgiveness program for service, but in reverse. Criteria for participants could include: degree in STEM discipline, 10 years of work in a STEM field, successfully completion of state-approved requirements to become a teacher, and service in a high-need school for at least three years.

A model that this program could be based on is the U.S. Department of Education's "Transition to Teaching" program that supports the recruitment and retention of mid-career professionals. In addition to supporting alternative routes for credentialing for professionals to become teachers, this program provides grants and other financial incentives. Financial support for teaching training may be another way the Federal Government can help retirees into the classroom.

A private effort worth mentioning is the IBM Transition to Teaching program. The government could help to replicate that model by providing tax breaks and other financial incentives for a company to implement a similar program.

Q6. What, in your view, should be the criteria for determining whether technology, instruments, or other project activities should be developed at NASA Centers or externally through competitive bidding?

A6. NASA Centers should focus upon technology that is of high value to NASA, but is too risky for industry to develop or of little or no commercial value. Much of this work will be for early development stages of a technology or instrument—low Technology Readiness Levels (TRLs)—where the focus is the development of the technology's basic capabilities (i.e., long before any set of requirements can be produced). Even at this stage collaboration with industry should be strongly encouraged. Once past this early stage, further development (mid-TRLs) is best accomplished through a fully integrated government/industry team where needs and requirements can be balanced with the ability of industry to build the product at a known and affordable cost. The final stage of development and the transition to a flight system (higher TRLs) is best accomplished by an industry led effort with government oversight.

Questions submitted by Representative Pete Olson

Q1. During our June 18 hearing, witnesses were in general agreement that converting NASA's spending authority to one-year money would create new hardships for the Agency. Could you elaborate on the consequences of such a change, and perhaps provide an illustrative example?

A1. One-year funds are not a cost-effective approach to the planning or implementation of multi-year programs. Limiting these funds leaves doubt regarding program continuation and provides little flexibility for the most efficient planning of program resources. The unintended effect of such a change would likely result in higher costs due to unknowns associated with program continuation.

Q2. Re-establishing Advanced Technology Development as an independently funded and managed program has been cited as an important reform if NASA is to enhance its capability to develop new and perhaps paradigm-shifting technologies. What caused the Agency to abandon this approach? Was it simply budget; was the return on investment in question? How much annual funding would be required to re-establish a credible program?

A2. An important part of NASA's charter has been to perform aerospace research which benefits its own future programs and the needs of industry. It would appear that the constraints on the Agency's budget caused more funds to be diverted and restricted the dollars available for basic research. This is a mistake and diminishes long-term research benefits. ATD is very important as it funds low-TRL technologies focused on NASA's needs, which are essential to the success of future missions. In addition, with regard to NASA aviation aeronautics, we believe that NASA should address the R&D needs of NextGen Air Traffic Modernization which involves both fundamental and higher-level in-close coordination with FAA.

Q3. The International Space Station will, in all likelihood, be utilized by NASA for some years beyond 2015 but at present the Agency appears unwilling to make such a commitment. Our international partner space-agencies have been looking for a firm signal from NASA for such a commitment, as it helps them deal with their governments to lay in long-term funding programs. What's preventing NASA from making such a commitment now?

A3. For NASA to commit to the ISS, the Agency needs presidential direction to continue the program. Later this summer the report by the Augustine Committee is expected to make recommendations on the extension of the ISS. It is likely that the White House will be able to confirm the extension of the ISS after the Augustine report is issued.

It would be helpful to have Congressional support for both an ISS extension to at least 2020 and additional ISS funding in a 2009 NASA Authorization bill.

Q4. What are your thoughts and concerns about engaging more intensively with international partners to fly joint missions? What are the primary disadvantages against joint missions, and in your view, would US science priorities likely be jeopardized if we aggressively engage in joint missions? To what degree do export control restrictions make joint missions unwieldy and difficult to manage?

A4. Joint missions would allow us to share costs and benefit from the talent of other nations. Such missions also allow for sharing of data and increased information sharing between nations and partners. Joint missions are also a valuable tool for maintaining or improving international relations. The disadvantage is that portions of missions that go overseas will not benefit our domestic industrial capacity, which in turn provides no benefit to our domestic industrial base in terms of workforce employed or R&D performed. This is a critical issue now for the United States if we want to sustain and lead in aerospace technology and capability. However, having additional partners does not preclude the potential for additional missions and ultimately more industrial and scientific productivity. Joint projects will have to be carefully planned, ideally with public-private-partnership approaches, and funded so that American tax dollars can stimulate the American economy and our domestic industrial base.

ITAR continues to complicate joint missions. Even when the U.S. and other nations have signed government to government agreements of cooperation, ITAR regulations still impact and delay support activities contracted to U.S. industry by NASA involving our foreign partners.

Q5. Re-invigorating NASA's workforce is especially critical given the average age of the Agency's employees. How would you describe the attractiveness of NASA as a prospective employer, especially from the perspective of a young 'fresh-out'? Would they tend to look at NASA as a career choice? How can NASA best ensure that the knowledge and 'lessons learned' will be passed from the current generation of scientists and engineers to the next?

A5. Public perception surveys of NASA (for example, see Dittmar Associates, *"The Market Study for Space Exploration,"* 2004 report) have found that young people, between ages 18–25, find very little excitement or interest in NASA or its activities—citing reasons such as general confusion about NASA's purpose and lack of relevancy.

Our industry also faces similar challenges with "fresh-outs." Recent surveys conducted by *Aviation Week* find that those with zero to five years experience are leaving our companies at higher rates than any other experience groups—especially those with an engineering or production laborer function.

The National Academies reported in 2006 that other factors in the near future will complicate NASA's workforce challenges, such as uncertainties about the future pace and scope of some program areas, program volatility and NASA's immediate needs for workers who already have significant experience, rather than more junior people who require training. These issues will very likely affect the perceptions of young people seeking careers at NASA and the industry.

With respect to 'passing knowledge down,' the aerospace industry does incorporate different knowledge management practices that NASA may consider. These tools include: apprenticeships, intranet portals, knowledge and content management systems, knowledge blogs, mentoring, information sharing events and aligning employee goals to knowledge management goals.

Additionally, many companies keep track of alumni—NASA may consider tracking an alumni's personal contact information, areas of expertise, work competencies, work history and current activities. NASA may also consider programs to connect with alumni such as: alumni association events, retiree consulting and extended work with reduced hours for alumni.

One thing that NASA appears to be doing well is in the area of social-networking. Use of these tools may be an effective way to communicate and pass knowledge to younger workers.

Q6. Over the last decade, NASA has employed several different financial management schemes that directly affect managers and the manner in which they account for and control—costs within their programs and missions. How effective, and how transparent, is the current system, especially from the perspective of program and mission managers?

A6. This question falls outside AIA's area of expertise.

Q7. NASA's aeronautics research and development program has beet severely reduced over the last decade, today only accounting for about three percent of the Agency's total budget. I find this alarming, considering NASA's origins as an outgrowth of NACA existed for more than 40 years prior to NASA's establishment. Two questions: (1) is the FY10 budget request sufficient to meet NASA's commitment to NextGen; and (2) if given an additional dollar for aeronautics R&D how would you spend it—what new activity or research would you pursue?

A7. Funding for NASA aeronautics R&D at the higher TRLs—4, 5, 6—has been in decline for years and that is exactly the kind of funding NextGen R&D needs. Now that President Obama has identified the fielding of NextGen as a national priority and Secretary LaHood and Presidential economic advisor Larry Summers have both asked government and industry to accelerate NextGen implementation by ten years, we really need additional research funding for key NextGen initiatives like aircraft self-separation and Unmanned Aerial Systems (UAS) integration. If we had an additional dollar to spend on aeronautics R&D, we would recommend spending 33 cents on aircraft self-separation, 33 cents on UAS integration and 34 cents on sustainable aviation biofuels.

Questions submitted by Representative Dana Rohrabacher

Q1. It is always easy to advocate for money for NASA. Assuming however, a relatively flat budget, especially for the years following 2010, what guidance can you offer regarding areas in NASA's budget: What areas are the highest priority to you, and what areas are the lowest priority? What can NASA or Congress do to maximize the science return on its budget?

A1. AIA represents almost all the companies that provide products or services to NASA, including all the mission directorates, making it difficult, if not impossible, for AIA to provide specific priorities. Clearly the work that NASA does is extremely important, difficult to categorize and. vital to our economy, national security and our future. AIA does believe, as stated in our recent report, *"The Role of Space in Addressing America's National Priorities"* that space should be coordinated at the highest level as a singular enterprise. Such a coordination body could help identify areas of overlap among all the federal agencies that deal with space issues, leading to significant cost savings. To help NASA in its critical projects, our nation should ensure that policy choices drive the budget rather than allowing the budget to shape and limit the scope of important policies.

Q2. We're all familiar with the large and growing threat that orbital debris poses to our people and assets in space. This subcommittee recently held a hearing on the topic. AIA recently hosted a briefing on this critical issue. I think you all would agree that it is critical for us to get working on some form of remediation effort.

Q2a. First—do you all agree on that?

A2a. AIA agrees that space debris is a serious issue that needs to be addressed.

Q2b. Second—is NASA the right agency to head this up?

A2b. NASA certainly has many of the critical skills needed to be a participant in solving this problem, but DOD currently tracks debris. Who takes the lead on this effort is a decision for the Administration and Congress. Industry is ready to work with the government on mitigating the impact of debris.

Q2c. Third—what are the hurdles we need to overcome to create an international effort to get rid of all this debris up there?

A2c. First, we need to improve the fidelity of our own space situational awareness to prevent conjunctions. We also need to work with our friends and allies in sharing information. Currently, the U.S. Government does not have the ability to remove debris from our space environment, although industry is investing in ways to "clean up" space. Additional support should be provided to the joint Air Force and National Reconnaissance Office Space Protection Program to assist their efforts to not only prevent the creation of additional space debris, but also look into ways to remove debris.

Q2d. Fourth—what are the proper roles for commercial entities to play in this?

A2d. We believe the aerospace industry has existing tools that can be employed in managing the data needed to mitigate space debris conjunctions and can also be a leader in future efforts to mitigate the effects of debris. We encourage government to include industry in discussions and plans for debris mitigation.

Q3. The recent Aerospace Safety Advisory Panel (ASAP) Annual report stated "From a safety standpoint the ASAP endorses the NASA position on not extending Shuttle operations . . . completing the ISS." *This leaves us with a gap in our domestic access to space. The ASAP report goes on to say* "we are not convinced that the Ares-I and Orion initial Operating Capacity date can be improved appreciably by additional resources. If we can't extend the Shuttle or move up

Ares I how can we best spend resources trying to minimize this gap?" *The report also states* "There is no evidence that COTS vehicles will be completed in time to minimize the gap. Except for inadequate funding is there evidence that COTS–D couldn't be available in time to reduce the gap?" *If NASA were to immediately fund these commercial efforts to modify existing launch vehicles and/or develop new ones what is the best case scenario for their availability?*

A3. Its clear NASA has a great deal of confidence in its Commercial Orbital Transportation Services (COTS) program, as it should, and we're very glad it is moving forward. However, only NASA can say when those systems will be ready to start human transport.

Q4. There is a renewed focus on NASA looking back at planet Earth. I have always thought that NASA did its best work looking outward. Isn't it time to shift some of these roles over to other agencies more fully so NASA can focus on looking out rather than looking in?

A4. The U.S. needs a robust Earth Observation capability to sustain our collection of critical global data. However, while Earth Observations are implemented through many agencies across the government, there is no overarching architecture to serve as the basis for research, development, applications and integration plans. A national long-range architecture is needed to guide plans that cross federal agency boundaries and leverage the contributions of academia and industry for effectively collecting and managing this important information.

Development of a national Earth Observation systems architecture can benefit from high-level directives with input provided by experts from government, academia, industry, and the private sector and reflect the interests and needs of the supply and demand sides of the market. The architectural blueprint should take a long view, with horizons out for at least two generations, as well as provide guidance in transitioning new technology research sensors and systems into the next generation of operational observing systems.

The Office of Science & Technology Policy (OSTP) is currently working on a policy related to this subject (United States Group on Earth Observations policy). AIA supplied approximately 25 pages of input to the OSTP which can be accessed at: *http://www.aia-aerospace.org/industry_information/reports_white_papers/*.

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