NASA'S FISCAL YEAR 2009 BUDGET REQUEST

HEARING

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES

ONE HUNDRED TENTH CONGRESS

SECOND SESSION

FEBRUARY 13, 2008

Serial No. 110–75

Printed for the use of the Committee on Science and Technology

Available via the World Wide Web: http://www.science.house.gov

U.S. GOVERNMENT PRINTING OFFICE

40–598PS WASHINGTON : 2008

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
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NASA'S FISCAL YEAR 2009 BUDGET REQUEST

WEDNESDAY, FEBRUARY 13, 2008

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

The Committee met, pursuant to call, at 10:07 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Bart Gordon [Chairman of the Committee] presiding.

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

Hearing on

NASA's Fiscal Year 2009 Budget Request

February 13, 2008
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

WITNESS LIST

Dr. Michael Griffin
Administrator
National Aeronautics and Space Administration

Section 210 of the Congressional Accountability Act of 1995 applies the rights and protections covered under the Americans with Disabilities Act of 1990 to the United States Congress. Accordingly, the Committee on Science & Technology strives to accommodate/meet the needs of those requiring special assistance. If you need special accommodation, please contact the Committee on Science & Technology in advance of the scheduled event (3 days requested) at (202) 225-6375 or FAX (202) 225-3895.

HEARING CHARTER

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

NASA's Fiscal Year 2009 Budget Request

WEDNESDAY, FEBRUARY 13, 2008
10:00 A.M.—12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Wednesday, February 13, 2008 at 10:00am, the Committee on Science and Technology will hold a hearing on the National Aeronautics and Space Administration's (NASA) Fiscal Year 2009 Budget Request and NASA's proposed Fiscal Year 2008 Operating Plan.

Witness:

Dr. Michael D. Griffin, Administrator, National Aeronautics and Space Administration

BACKGROUND INFORMATION

Overview

The National Aeronautics and Space Administration (NASA), which was established in 1958, is the Nation's primary civil space and aeronautics R&D agency. The current civil service workforce consists of approximately 18,400 employees, of which approximately 16,310 are full-time, permanent civil servants. NASA has ten field Centers, including the Jet Propulsion Laboratory (JPL) FFRDC. Although there have been discussions in the past regarding the future disposition of NASA's Centers (e.g., potential closure or privatization of one or more Centers), NASA Administrator Griffin has stated his intention to maintain "ten healthy Centers." In October 2007, NASA assigned work for the Exploration initiative's Constellation Program to each of the ten NASA Centers.

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 also maintains a space communications network that supports both NASA missions and other federal agency requirements. Almost 90 percent of NASA's budget is for contracted work. In addition, a number of NASA's scientific and human space flight activities involve collaboration with international participants.

In January 2004, President Bush announced his "Vision for U.S. Space Exploration" (VSE). According to the President, the United States is to do the following:

- *"Implement a sustained and affordable human and robotic program to explore the solar system and beyond;*
- *Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;*
- *Develop the innovative technologies, knowledge, and infrastructures both to explore and support decisions about the destinations for human exploration; and*
- *Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests."*

With respect to the Space Shuttle, the President's policy stated that NASA should:

- *"Focus use of the Space Shuttle to complete assembly of the International Space Station; and*
- *Retire the Space Shuttle as soon as assembly of the International Space Station is completed, planned for the end of this decade."*

With respect to development of a new human transportation system, the President's policy states that the U.S. shall:

- *"Develop a new crew exploration vehicle to provide crew transportation for missions beyond low Earth orbit;*
- *Conduct the initial test flight before the end of this decade [i.e., before end of 2010] in order to provide an operational capability to support human exploration missions no later than 2014."*

Budgetary Information

NASA's proposed budget for FY 2009 is $17.6 billion, an increase of 1.8 percent over the FY 2008 President's request for NASA and an increase of 2.9 percent over the FY08 appropriation for NASA, when the recession of $192.5 million contained in the *Consolidated Appropriations Act for 2008* [P.L. 110–161] is added. Attachment 1 summarizes the FY09 budget request and its five-year funding plan. It should be noted that NASA's budget has been restructured from three main appropriations accounts—Science, Aeronautics, and Exploration; Exploration Capabilities; and Inspector General—to seven accounts—Science; Aeronautics; Exploration; Space Operations; Education; Cross Agency Support; and Inspector General—as directed in the *Consolidated Appropriations Act* for FY08. As part of the budget restructuring, NASA shifted from a full-cost budget, in which each project budget included overhead costs, to a direct cost budget. All overhead budget estimates are now consolidated into the Cross Agency Support budget line. NASA has stated that maintaining a full cost budget with seven appropriations accounts would be overly complex and inefficient. The direct cost budget shows program budget estimates that are based entirely on program content. Individual project managers continue to operate in a full-cost environment, including management of overhead costs.

Attachment 2 compares the NASA budget plan that accompanied the President's Vision initiative with the actual funds requested (or planned to be requested per the FY09 budget request's five-year plan) by the President for the years FY06–FY13. As can be seen, the President's requests 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 by the Administration 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 FY08 appropriation for NASA contained in the *Consolidated Appropriation Act of 2008* maintains the President's FY08 request of $17.3 billion for NASA. Under the terms of the Consolidated Appropriation, NASA is to submit to Congress by March 15, 2008 an Operating Plan that reflects how the agency will allocate its FY08 appropriation within the constraints of the Consolidated Appropriation. Administrator Griffin has been asked to discuss the FY08 Operating Plan at the hearing.

To put the FY09 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; assembling, operating, and utilizing the International Space Station; completing the development of a new Crew Exploration Vehicle/Crew Launch Vehicle by 2014; pursuing human exploration of the Moon no later than 2020; and conducting science and aeronautics programs. The *NASA Authorization Act of 2005,* which was signed into law in December 2005, authorized an FY08 funding level for NASA of $18.69 billion; the FY08 NASA budget request and appropriation was $17.3 billion, not including $192.5 million in rescissions as directed. The Committee intends to reauthorize NASA this year.

With respect to NASA's contract management practices, NASA remains on GAO's "high risk" list for its contract management practices. With respect to its financial management, an independent audit for FY07 was unable to provide "an opinion on the consolidated balance sheet as of September 30, 2007." Although NASA took several actions to comply with the *Federal Financial Improvement Act of 1996,* the audit found that the agency's financial management systems "are not substantially compliant" with the Act. NASA will need to address other "material weaknesses" identified in the audit.

Program Areas

Space Science

The President's FY09 budget requests $3.1 billion in direct program dollars (previous budget requests were prepared in full cost accounting and included overhead costs) to fund NASA's space science programs, including Heliophysics, which seeks to understand the Sun and how it affects the Earth and the solar system; Planetary

Science, which seeks to answer questions about the origin and evolution of the solar system and the prospects for life beyond Earth; and Astrophysics, which seeks answers to questions about the origin, structure, evolution and future of the universe and to search for Earth-like planets. The proposed budget represents an effective decrease of $264.7 million in direct program dollars from the FY08 appropriation. Most of that decrease is attributed to a transfer of the management and budget for ground based communications systems—Deep Space Mission Systems and Near Earth Networks programs—from the Heliophysics Division to the Space Operations Mission Directorate, which is implementing a plan to consolidate all of NASA's communications activities into its Space and Flight Support Program.

Space Science topics and issues related to the FY09 budget request include the following:

Programmatic Balance and New Initiatives—The FY09 budget request provides increases (as compared to the FY08 budget appropriation) for research and analysis (R&A) programs, which fund grants to analyze science mission data and are an important means of training future space scientists and engineers. R&A accounts had been cut in the recent years, a trend that threatened the health of space science disciplines. The FY09 request increases funding for small mission projects (balloons, airborne platforms, and small space missions) that help train young scientists and engineers and provide frequent opportunities for science return. The President's FY09 budget initiates work on a flagship planetary science mission to the Outer Planets (Jupiter's moon Europa, and Saturn's moon Titan are two possible destinations) and a joint mission with DOE, Joint Dark Energy Mission (JDEM), to investigate dark energy in the universe. The FY09 budget includes plans to begin studies on a "cost constrained Solar Probe mission" that would improve our understanding of the solar wind. It also includes funding to explore technical approaches for a medium-class mission to detect and characterize exoplanets that would be initiated in FY10. This effort is intended to replace the Space Interferometry Mission (SIM) that was previously reduced to a technology development activity by NASA, a decision reversed by the Omnibus appropriations act, which included an explanatory statement that said "With the funds proposed, NASA is to begin the development phase of the [SIM] program. . ." NASA also includes $67.3 million in support of a Mars Sample Return mission to take place in 2018 and 2020. Most of the proposed new missions have been identified as priorities in National Research Council reports. NASA has indicated that it will phase these initiatives to fit within the budget, however the bulk of development costs will occur toward the middle of the next decade, which is beyond the horizon of the FY09 budget and its five-year run-out. In addition, the new initiatives are not supported by a new infusion of funding into the overall science account; new initiatives in Earth and space science are paid for by cutting back funding in other science areas.

Mars Exploration—The FY09 budget request reduces the programmatic content in the Mars Exploration budget by $156.5 million from the FY08 appropriation. The FY09 decrease results from moving funds that were allocated to a 2011 Mars Scout mission [now scheduled for 2013] to help fund new initiatives in the Earth sciences program. The President's FY09 request decreases the Mars Exploration budget by $918 million, in direct dollars, for FY09 through FY12. NASA's plans for Mars Exploration include the launch of a Mars Science Laboratory in 2009, a Mars Scout mission in 2013 and a 2016 mission that has yet to be defined.

After 2013, NASA plans to focus the program on developing a Mars Sample Return mission, which has been a high priority in National Research Council (NRC) reports. The President's FY09 budget request does not include funds to initiate a Mars Sample Return. According to NASA officials, a Mars Sample Return mission would be launched in two parts, in 2018 and 2020, and would cost in the range of $4 billion dollars, some fraction of which NASA anticipates to be funded by international partner(s). NASA plans to conduct architecture studies over the next year and is discussing potential international collaboration on a sample return mission. A National Research Council report released in late 2007, *Grading NASA's Solar System Exploration Program: A Midtern Review,* raised several concerns regarding a future Mars Sample Return mission including the need for investment in a technology development program to reduce the major engineering risks associated with a Mars Sample Return mission. These engineering challenges are likely to require long lead times to ensure the technology is mature in preparation for a mission's development phase. A topic that may be raised at the hearing is what the potential shift in NASA's Mars Exploration program is and how the science and engineering community is involved in this change in focus.

Ambitious Program Containing Several Major New Initiatives—The President's FY09 budget requests funds for several new space science initiatives, many of which have estimated budgets over $500 million and are anticipated to launch with international or interagency collaboration:

Outer planets mission—NASA estimated level of $2 billion for U.S. portion

New Frontiers mission—NASA estimated level of $840 million

Joint Dark Energy mission—NASA estimated level of $600 million for NASA

Exoplanet mission—NASA estimated level of $600 million for NASA

Solar Probe mission—NASA estimated level of $750 million

Large, complex missions have the potential to encounter technical challenges, and there are a number of past examples of such missions that have encountered similar instances of cost growth and schedule delays. Members may wish to ask NASA for specific details on its approach to successfully completing these initiatives within a budget limited to inflationary growth.

Technology Development—Recent NRC reports recommend that NASA invest in technology development outside of the mission project lines. One NRC report states, *"The committee is concerned because NASA has not invested in required technology and shows little indication of reversing this trend. If this trend is not reversed immediately, the number and types of missions that the agency will be able to undertake in the future will be severely reduced."* Inadequate technology development has been identified as a major factor in mission cost growth. The President's FY09 budget request cuts technology development program lines and continues the trend noted by the NRC. For example, the FY09 budget virtually cancels a flight technology validation program and cuts programmatic content for technology development in the planetary sciences by $65.7 million over the FY09–FY12 period. NASA officials told Committee staff that technology development will occur within the mission budget lines as needed. Members may wish to probe the implications of the proposed cuts to NASA's technology development programs on NASA's ability to pursue several new missions and to maintain schedule and cost discipline in executing them.

Congressional Direction—The President's FY09 budget request supports Congressional direction for NASA to initiate an outer planets mission and a Joint Dark Energy Mission, but departs from Congressional direction for NASA to begin development of the Space Interferometry Mission. NASA's plan for SIM is to consider its technical approach as one of several candidates that will compete for an exoplanet mission. The FY08 consolidated appropriation provides full funding and support for the Mars Exploration Program, while the FY09 budget request cuts the program over the FY09–FY12 period. The FY08 appropriation directs NASA to request a new start for a Solar Probe mission in FY09, however the FY09 budget requests no funds in FY09 and only $3.4 million in FY10 for initial concept work on a Solar Probe mission that it plans to launch by 2015. The explanatory text accompanying the FY08 appropriation supports the Arecibo Observatory and directs NASA to provide additional funding for Arecibo. NASA officials told Committee staff that the FY09 budget does not include any NASA funds or plans for Arecibo and that NASA did not need Arecibo. The explanatory text accompanying the FY08 appropriation for NASA notes Congressional support for the Alpha Magnetic Spectrometer (AMS) experiment, which was intended to fly on the Shuttle for attachment to the ISS, and directed NASA to prepare a report, within 30 days, on options for flying AMS. NASA, to date, has not provided Congress with the report.

Earth Science

The President's budget for FY09 requests $1.4 billion in direct dollars for Earth science research, applications, Earth observing missions, education and outreach, and technology development. The proposed FY09 Earth science budget represents an increase of approximately $87.2 million over the FY08 budget appropriation, as compared in direct dollars. The FY09 budget requests $910 million over the FY09–FY13 period to execute five new missions based on recommendations in the National Research Council's Earth sciences decadal survey. $570 million is made available from cuts to the science programs and the rest is obtained restructuring other Earth Science activities. The first two missions are identified as the Soil Moisture Active-Passive (SMAP) and ICESat-II; the additional three will be identified by the end of 2008, one of which will be a technology demonstration mission in the $100–$200 million range. NASA's Earth science budget also requests funds to continue several missions currently under development, including the Landsat Data Continuity Mission, the Glory mission, the NPOESS Preparatory Project (NPP), the Global Precipi-

tation Measurement mission (GPM), Aquarius, and the Orbiting Carbon Observatory.

The proposed FY09 budget requests increases to the Earth science research and analysis (R&A) accounts reversing a trend of cuts and flat funding in previous budget requests. The R&A accounts fund grants for fundamental research, technology development, training of graduate students, theory research, and data analysis, in essence the intellectual underpinning for the program.

Earth Science topics and issues related to the FY09 budget request include the following:

Research to Operations—The 2005 *NASA Authorization Act* directs NASA to prepare a report with the National Oceanic and Atmospheric Administration (NOAA) each year, on how Earth science programs will be coordinated in the following year. The Act also directs NASA to provide transition plans for "existing and future Earth observing systems found to have potential operational capabilities." The first plan, which was delivered to Congress in June 2007, identified forums that have been established to coordinate NASA and NOAA Earth science programs. Over the last year, NASA and NOAA have coordinated plans to address climate measurements that were eliminated in the restructuring of the NPOESS program and in planning for the GOES–R system, among other activities. The decisions have not come easily and have involved consultation with OSTP and OMB and input from the National Research Council. Even with this process, decisions have only recently been made to restore climate instruments to the NPOESS Preparatory Project (NPP). NASA has not yet manifested the Total Solar Irradiance Sensor (TSIS) to a satellite platform, however an announcement is expected in March 2008. Within the next few years, several Earth science missions will be launched and NASA will begin to formulate new missions in response to the Earth science decadal survey; planning for research to operations will be an important consideration. It is not clear whether or not the FY09 request incorporates a budget for planning and transitioning research to operations.

Earth Science Applications—The National Research Council's Earth sciences decadal survey recommended that *"Socioeconomic factors should be considered in the planning and implementation of Earth observation missions and in developing an Earth knowledge and information system."* The FY08 Consolidated Appropriation provided $15 million in additional funds for NASA's Applied Sciences program, which applies the research results of NASA's Earth science missions to decision-making tools in the areas of climate, ecosystems, agriculture, water, disaster management and other areas that benefit society. Members may wish to ask whether NASA plans any changes to the Applied Sciences program in keeping with the emphasis on the societal benefits of Earth science research that was discussed in the decadal survey. Members may wish to ask more specifically whether NASA's Applied Sciences programs include, or plan to include, activities that would help State, local, private, and federal bodies adapt to and mitigate the impacts of climate change discussed in the Intergovernmental Panel on Climate Change (IPCC) assessments.

Aeronautics Research

The President's FY09 budget requests $446.5 million for Aeronautics Research, which includes aviation safety, airspace systems, fundamental aeronautics, and aeronautics test program. NASA states that its Aeronautics Research is now aligned with the National Aeronautics R&D Policy and the National Plan for Aeronautics R&D and Related Infrastructure, which were developed by the Administration over the past two years. From a direct cost perspective, the FY09 budget for Aeronautics represents an effective $65.2 million decrease from the FY08 appropriation. After FY09, the NASA Aeronautics funding would essentially stay level through FY13, thus continuing to decline in purchasing power. As a point of comparison, NASA Aeronautics funding was about $1.85 billion (2006 dollars) in 1994—the current budget request is thus only about 24 percent of that level.

The aeronautics community relies upon NASA for aeronautical research and development. Beginning in late 2005, NASA began restructuring its aeronautics program to move away from a program that included technology demonstration projects and R&D that led to greater technology maturity towards a program focused on more fundamental research. These changes in NASA's Aeronautics program occur at a time when the Next Generation Air Transportation System R&D initiative known as NextGen is ramping up. NextGen is intended to transform the existing air traffic control system to accommodate projected growth in air passenger and cargo rates over the next decade. As part of this modernization, NextGen aims to develop a more efficient; and more environmentally friendly national air transpor-

tation system, while maintaining safety. The development of NextGen is being overseen by the Joint Planning and Development Office (JDPO), a joint initiative of the Department of Transportation, NASA, Commerce, Defense Homeland Security, and the White House OSTP. FAA has traditionally relied on NASA for a significant portion of the R&D related to air traffic management as well as research to help address substantial noise, emissions, efficiency, performance, and safety challenges that are required to ensure vehicles can support the NextGen vision.

Aeronautics topics and issues related to the FY09 budget request include the following:

Potential "Technology Gap" for NextGen—NASA's redirection of its aeronautics research priorities raised Congressional concern last year regarding the possibility of a significant "technology gap" in a number of key NextGen technology areas. While some progress has been made in the past year as a result of JDPO's completion of concept of operations, planning and architecture documents (and the first ever plan for research and development, including agency roles and responsibilities), much work remains to be done in adequately planning, resourcing, and scheduling research activities. The $25 million reduction in NASA's budget from FY08 to FY09 for Airspace Systems—which funds the agency's air traffic management work in support of NextGen—does not generate confidence in NASA's ability to meet its future JDPO responsibilities and specifically in affecting the "technology gap" in an urgent manner.

International Space Station

The President's FY09 NASA budget requests $2.06 billion for the International Space Station (ISS) program for on-orbit assembly, launch processing activities, operations and continuation of research payload and experiment deliveries to orbit. The FY09 budget funds the delivery and operation of the habitability modifications to allow an increase in ISS crew size to six. Up to this point, the ISS was limited to three crew members, thus limiting the amount of research that could be performed as assembly and operational responsibilities required considerable attention. NASA's plan to complete the ISS will meet the commitment to the International Partners. In addition, a key challenge facing the ISS Program will be the need to purchase alternate cargo and crew transportation services after the Shuttle is retired, which is scheduled for 2010. NASA's FY09 budget request includes $2.6 billion for the purchase of cargo transportation services over five years, $600 million of which is committed to purchases of crew transportation from Russia through FY11. From a direct cost perspective, the proposed FY09 budget represents an effective increase of $247 million from that appropriated in FY08.

ISS topics and issues related to the FY09 budget request include the following:

ISS Cargo and Crew Transportation Services In the Post-Shuttle Era—The Commercial Crew and Cargo Program is NASA's effort to foster the development of a cost-effective commercial space transportation capability for the post-Shuttle Era. This capability will initially be utilized to carry cargo to the ISS; future options could involve developing a crew transportation capability. The development of the commercial cargo/crew transportation capability is being funded in the Constellation budget. Once the services have been demonstrated, the operational responsibility for the program will move to the ISS program within the Space Operations Missions Directorate.

As the Space Shuttle nears retirement, NASA's stated preferred solution for ISS crew and cargo delivery and return requirements is to use commercial services provided by space transportation companies. NASA's Commercial Orbital Transportation Services (COTS) project is intended to facilitate U.S. private industry's development of cargo and crew space transportation capabilities with the goal of demonstrating reliable, cost effective access to low Earth orbit. NASA had initially selected two partners for its COTS project under Space Act Agreements. One partner failed to meet NASA's milestones and NASA terminated the Agreement. With the recent GAO decision rejecting a challenge by the terminated partner to NASA's plans to utilize a Space Act Agreement rather than a government contract, NASA is now working toward choosing one or more additional funded partner(s), and a decision is expected in February 2008. If NASA's preferred solution of using commercial services is not attainable, NASA will need to rely on alternatives such as continued purchases of Russian Progress vehicles, European Automated Transfer Vehicles (ATV), or Japanese H–II Transfer Vehicles (HTV). Those alternatives, however, would require some time to procure. Furthermore, purchases of Russian capabilities beyond 2011 will require negotiations to address requirements of the *Iran, North Korea and Syria Non-Proliferation Act* (INKSNA). A Request for Proposals (RFP) will be sent out for Phase 2 of the COTS program in April 2008 with a contract

award by the end of the year. An issue that could be raised at the hearing is when the State Department would need to initiate negotiations to ensure NASA does not face a shortfall in cargo transportation capability—should it be forced to purchase such capabilities from Russia.

Establishing ISS Program Service Life—NASA indicates that while the FY09 budget run out does not presently allocate funds for operating ISS beyond 2016, it is not taking any action to preclude it. Likewise, out year projections do not include costs to retire and decommission ISS. An issue that could be addressed at the hearing is what impact a possible U.S. departure would have on the ISS international partners.

International Space Station Research—The ISS is intended to serve as an on-orbit facility where R&D in support of both human exploration and non-exploration purposes and other exploration technologies is to be conducted. However, the ISS research budget, which is book-kept in the Exploration Systems (ESMD) budget has been significantly cut back in recent years to help fund the Crew Exploration Vehicle/Crew Launch Vehicle and for other purposes.

Space Shuttle

The President's FY09 budget requests $2.98 billion to operate and maintain NASA's three Space Shuttles, and to conduct five ISS assembly flights in FY09. Assembly flights include the launch of the last major power element for the ISS and other significant infrastructure and international partner hardware. From a direct cost perspective, the proposed budget represents an effective decrease of $285 million from that appropriated in FY08.

Space Shuttle topics and issues related to the FY09 budget request include the following:

Maintaining the flight schedule—NASA plans to complete six Shuttle flights in FY08—five for ISS assembly and one Hubble Space Telescope servicing mission. In FY09, NASA plans to fly five additional missions. This tempo has not been achieved since the *Columbia* accident. So while NASA should be commended for not allowing schedule pressures to detract from its safety focus, the frequent delays encountered since return to flight after the *Columbia* tragedy pose daunting challenges to the agency's flight manifest and its plan to conduct all missions in the window available.

Fly-out of Planned Shuttle Missions—NASA's Shuttle manifest shows two logistics flights before the Space Shuttle is retired by the projected September 2010 date. However, the Administration has not committed to completing these two so-called "contingency" flights although the funding necessary to accomplish them is included—assuming the flights are carried out by October 2010. Furthermore, as previously indicated, the window for all Shuttle flights grows smaller when missions are delayed and may have an impact on whether these two logistics missions can be flown. These two missions will carry spares for the ISS that only the Space Shuttle can accommodate, and the program considers the flights as necessary rather than "nice-to-have." Provision of such spares is paramount to maintaining the extended health of the ISS.

Space Shuttle Program Transition and Retirement—There will be a significant level of effort required for program shutdown after the Shuttle's retirement in FY10. NASA's FY09 budget request's five-year plan does not include funds or a plan to address Space Shuttle program transition and retirement past FY10 even though NASA acknowledges that there will be costs associated with the shutdown. While NASA indicated that concrete plans and budgets would be included in the FY09 request, this did not materialize. NASA recently told the Committee that initial cost estimates for transition that reached into the billions of dollars are still being refined and that the agency's present goal is to bring this down to less than $500 million. Currently, NASA estimates the cost at approximately $1.2 billion. According to NASA, attainment of this level of reduction is dependent on decisions to be made on the state in which the orbiters will be preserved and what Space Shuttle buildings and facilities can be effectively used by the Constellation Program or others. In addition, a drastic "step function" may occur in the number of Civil Service Full Time Equivalents (FTEs) and the number of contractor personnel supporting the Space Shuttle. NASA is currently refining its schedule for moving personnel off of the Space Shuttle. The most recent estimates for personnel remaining on the Shuttle program by year are listed below:

	FY 07	FY 08	FY 09	FY 10	FY 11
Civil Service FTEs	1,765	1,805	1,741	1,671	0
Contractor personnel	16,105	15,395	13,698	11,023	0

Exploration Initiative

The President's proposal for NASA's FY09 budget provides $3.50 billion for Exploration Systems to fund Constellation Systems, which includes the development, demonstration, and deployment of the Orion Crew Exploration Vehicle (CEV) and the Ares I Crew Launch Vehicle (CLV) as well as associated ground and in-orbit infrastructure; and Advanced Capabilities, which includes human research to support ISS and future exploration; a lunar precursor robotic program; microgravity research; and technology development to support Orion and other exploration programs. From a direct cost perspective, the proposed FY09 budget represents an increase of $357.4 million from that appropriated in FY08. In addition, the President's request for the Constellation program increases from that appropriated in FY08 by $576.3 million.

Exploration topics and issues related to the FY09 budget request include the following:

CEV and CLV schedule and budget—The President's Vision statement directed NASA to have the CEV operational no later than 2014. The *NASA Authorization Act of 2005* directed the NASA Administrator *"manage human space flight programs to strive to achieve. . .launching the Crew Exploration Vehicle as close to 2010 as possible"* subject to the proviso that the Administrator shall *"construct an architecture and implementation plan for NASA's human exploration program that is not critically dependent on the achievement of milestones by fixed dates."* NASA originally said that its budget plan would deliver an operational CEV in 2014. However, in FY07, NASA concluded that *"As a result of this analysis over the past two months, the FY 2008 budget request does not support a 2014 initial operational capability, but March 2015, even before the FY07 CR impact. . ."* At last year's budget hearing before the Committee, the NASA Administrator said that while the reduction in funding caused by the 2007 Continuing Resolution extended the operational date to September of 2015, NASA terminated some lower priority activities to buy back some schedule for the CEV. This returned NASA to the March of 2015 date. The FY09 budget request funds activity levels that maintain NASA's commitment to reach initial capability for both Orion and Ares I by March 2015 and thus does not permit acceleration of such operational capability. However, NASA states that while it can only commit to the March of 2015 date, it will strive to improve upon that milestone, to effectively reduce the gap in U.S. manned transportation capability caused by the retirement of the Space Shuttle. Meeting this date will require timely resolution of design issues that have surfaced, particularly in the Ares I program. An October 2007 GAO report on Ares I found that *"requirements instability," "technology and hardware development knowledge gaps,"* an *"aggressive schedule,"* and *"projected funding shortfalls"* represent significant challenges for the program. Although NASA states that threats to Orion and Ares I projects are being worked through using a rigorous risk management process, an area of concern due to its potential impact on NASA's ability to maintain its scheduled operational date of March of 2015 is the level of reserves through FY10. These are characterized by NASA as minimal, less than eight percent. Another area of concern that could have ramifications for weight and cost is whether Orion will be designed to make land or water landings. A decision from NASA is expected by March of 2008.

Reduced funding of Exploration Technology Development—The Exploration Technology Development Program (ETDP) provides new technologies that will enable NASA to conduct future human missions and reduce risk and life cycle cost. ETDP investments reduce the risk of infusing new technologies into flight projects by maturing them to the level of demonstration in a relevant environment. For example, one project is developing technologies for atmospheric management, environ-

mental monitoring and control, advanced air and water recovery systems, and waste disposal for use inside crew habitats. Despite the critical role technology development plays in reducing the risks of future space travel, funding for exploration technology development is being reduced by $42.9 million from that appropriated in FY08. Funding surpassing that provided in FY08 is not projected to occur until FY10 at the earliest.

Lunar Robotic Precursor Program (LRPR)—NASA's LRPR includes the Lunar Reconnaissance Orbiter (LRO), which will take high-resolution images of the Moon, map resources, and assess the lunar environment for future exploration, and the Lunar Crater Observation and Sensing Satellite (LCROSS), which will explore the darker region at the lunar poles. The combined mission is scheduled to launch in late 2008 on an Atlas V. The LRPR will also manage the development of two small lunar landers that are being initiated through the Science Mission Directorate's FY09 budget plans.

Space Communications

The President's FY09 budget requests $582.9 million for Space Communications and Navigation, about $280 million above the FY08 appropriation, as compared in direct dollars. Most of the increase was acquired from the transfer of the Deep Space Network and Near Earth Network from the Science Mission Directorate. The transfer was part an effort to consolidate the management and budget for all space communications activities within the Space Operations Mission Directorate. The FY09 budget includes $154 million to develop two replacement satellites for the Tracking and Data Relay Satellite System (TDRSS), which provides in-orbit communications links between on-orbit systems [e.g., the Shuttle, ISS, Hubble, and near-Earth orbiting satellites]. Other agencies also rely on TDRSS. The communications support provided by TDRSS is projected to decline by 2011. These replacements will ensure TDRSS support until 2016.

Deep Space Network—In a report to the Committee in April 2006, the GAO raised concerns about the DSN's aging and fragile infrastructure. While NASA is working toward consolidating its space communications into a single integrated network architecture, an issue that could be raised at the hearing is why NASA, despite warnings about aging, DSN's funding for the next five years is essentially flat.

Education

The President's budget proposes $115.6 million in FY09 to support NASA's Education program, including projects targeted at higher education, minority university research and education, elementary and secondary education; and the E-education project, which supports development of technology products, services, and applications, as the informal education project, which seeks to expand student, educator, and public learning in STEM areas. The proposed FY09 budget represents a reduction of $10 million from the FY08 budget appropriation. The cuts were allocated across the portfolio of programs. A recent National Research Council review of NASA's K–12 education program recommended an increased use of partners in its pre-college education programs, definition of realistic project goals, and development of a plan for project and program evaluations.

In addition to the projects included in NASA's education office, the Science Mission Directorate, for example, includes educational programs through some of its divisions and individual space missions. Members may wish to ask whether NASA is taking appropriate steps to maximize the effectiveness of the agency's investments in education, including how these investments relate to STEM education.

Attachment 1

FY 2009 Budget Request

Budget Authority, $ in millions By appropriation account By Theme	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Science	**$4,609.9**	**$4,706.2**	**$4,441.5**	**$4,482.0**	**$4,534.9**	**$4,643.4**	**$4,761.6**
Earth Science	$1,198.5	$1,280.3	$1,367.5	$1,350.7	$1,250.9	$1,264.4	$1,290.3
Planetary Science	$1,215.6	$1,247.5	$1,334.2	$1,410.1	$1,537.5	$1,570.0	$1,608.7
Astrophysics	$1,365.0	$1,337.5	$1,162.5	$1,122.4	$1,057.1	$1,087.7	$1,116.0
Heliophysics	$830.8	$840.9	$577.3 *	$598.9	$689.4	$741.2	$746.6
Aeronautics	**$593.8**	**$511.7**	**$446.5**	**$447.5**	**$452.4**	**$456.7**	**$467.7**
Exploration	**$2,869.8**	**$3,143.1**	**$3,500.5**	**$3,737.7**	**$7,048.2**	**$7,116.8**	**$7,666.8**
Constellation Systems	$2,114.7	$2,471.9	$3,048.2	$3,252.8	$6,479.5	$6,521.4	$7,080.5
Advanced Capabilities	$755.1	$671.1	$452.3	$484.9	$568.7	$595.5	$586.3
Space Operations	**$5,113.5**	**$5,526.2**	**$5,774.7**	**$5,872.8**	**$2,900.1**	**$3,089.9**	**$2,788.5**
Space Shuttle	$3,315.3	$3,266.7	$2,981.7	$2,983.7	$95.7	$0.0	$0.0
International Space Station	$1,469.0	$1,813.2	$2,060.2	$2,277.0	$2,178.4	$2,448.2	$2,143.1
Space and Flight Support (SFS)	$329.2	$446.3	$732.8 *	$612.1	$626.0	$641.7	$645.4
Education	**$115.9**	**$146.8**	**$115.6**	**$126.1**	**$123.8**	**$123.8**	**$123.8**
Cross-Agency Support	**$2,949.9**	**$3,242.9**	**$3,299.9**	**$3,323.9**	**$3,363.7**	**$3,436.1**	**$3,511.3**
Center Management and Operations	$1,754.9	$2,013.0	$2,045.6	$2,046.7	$2,088.0	$2,155.3	$2,211.6
Agency Management and Operations	$971.2	$930.2	$945.6	$945.5	$939.8	$950.5	$961.3
Institutional Investments	$223.8	$319.7	$308.7	$331.7	$335.9	$330.4	$338.3
Congressionally Directed Items	$0.0	$80.0	$0.0	$0.0	$0.0	$0.0	$0.0
Inspector General	**$32.2**	**$32.6**	**$35.5**	**$36.4**	**$37.3**	**$38.3**	**$39.2**
*FY08 Rescission***		*($192.5)*					
NASA FY 2009	**$16,285.0**	**$17,116.9**	**$17,614.2**	**$18,026.3**	**$18,460.4**	**$18,905.0**	**$19,358.8**
Year to Year Change		5.1%	2.9%	2.3%	2.4%	2.4%	2.4%

Budgets include all direct costs required to execute the programs. Indirect costs are now budgeted within Cross-Agency Support.

* Deep Space and Near Earth Networks Transfer ($256M) to SFS in FY 2009

** FY08 Appropriation rescinded $192.475M in prior-year unobligated balances, effectively reducing FY 2008 authority.

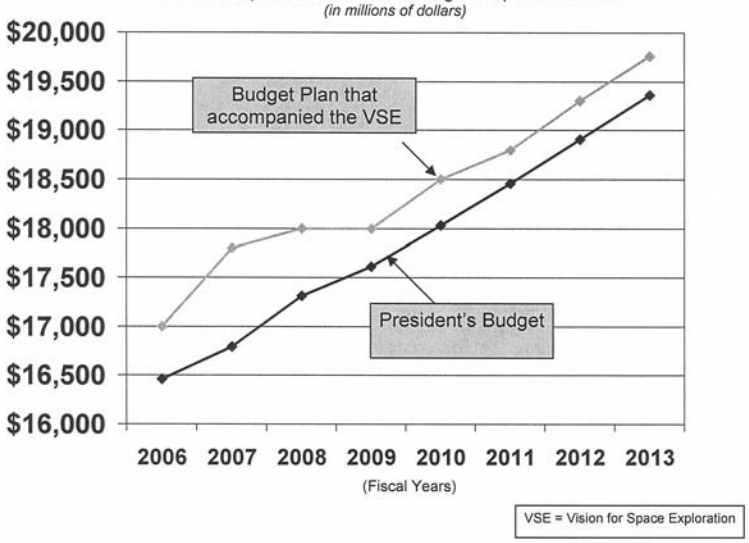
Source: NASA

FY08 budgets are the enacted levels per the Agency's FY 2009 Budget Estimates. Totals may not add due to rounding

Attachment 2

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

(in millions of dollars)



Chairman GORDON. Welcome, everyone. I know this is a bit of an odd day because of the snow. Mr. Udall and I rode. Mr. Udall was stuck, but he was supposed to have arrived at the airport at a quarter until 10:00, and so hopefully he is on his way, and I am sure other Members are dealing with their own various problems. But Dr. Griffin, we, you were here on time, and we respect that and feel like that we need to move forward this important hearing.

So with that, this committee will come to order.

Today's hearing will be Congress's first opportunity to review the President's fiscal year 2009 NASA budget request. The fiscal year 2009 budget request is not just a collection of funding levels and program descriptions. Rather, it defines the Administration's priorities for NASA and its vision for what NASA should be doing in the coming years.

In that regard, this budget request and Congress's disposition of that through the authorizing and appropriations process this year will in large measure define the state of the Space and Aeronautics Program that will be inherited by the next President. So the stakes are high.

As many of you know, this year marks the 50th anniversary of the dawn of the U.S. Space Program and the establishment of NASA. It also marks the 50th anniversary of the establishment of the Science and Technology Committee. We and NASA were a direct result of the Soviet Sputnik launch, an event that sent shockwaves throughout the American Government and the American public. In fact, our committee was established in part to help define an appropriate American response to Sputnik and to oversee America's fledgling Space Program.

Now, 50 years after NASA's birth I think that this committee needs to take a hard look at where NASA is headed and whether or not the course that the current administration has set NASA on is an appropriate one and one that should be followed by the next Administration, whether it be Democrat or Republican. We need to develop a Congressional consensus on what NASA should be doing and equally important, on what level of resources this nation is willing to commit to NASA.

I thought we had achieved such a consensus in the *NASA Authorization Act of 2005,* which was passed by the Congress and signed by the President. Yet the Administration's actions since that time, unfortunately, have not helped to maintain that consensus. In particular, I believe that the Administration has to date failed to provide resources to NASA that are adequate for what it has asked NASA to do and what it agreed in the Authorization Act.

And that is not just my opinion. If you review our committee's hearings over the past several years, you will find bipartisan expressions of concern over the mismatch between NASA's tasks and the resources it has been given. We see the impact of that approach to NASA through the budget request that we are reviewing today.

Thus, we see an Aeronautics Program that continues on a downward path, despite clear consensus or Congressional direction that echoes our belief that NASA's aeronautics R&D activities are critical to our competitiveness, the safety and effectiveness or efficiency of our aviation system, and our quality of life, and despite

clear evidence that our current air traffic control system is antiquated and under severe stress.

In the science area, the situation is uncertain. The good news is that NASA has at least taken steps consistent with Congressional urging and direction to initiate new Earth science missions recommended by the National Academies in its recent Decadal Survey.

The bad news is that the funding for those Earth science missions doesn't reflect any new commitment on the part of the Administration to enhance NASA's overall Science Program. Instead, funding for those missions will be provided by shifting money from other Earth science research activities as well as other NASA science accounts in the coming years.

In short, a musical chairs approach to science funding. Yet the successive cuts to NASA's aeronautics portfolio and uncertain outlook for NASA Science Program have not resulted in any corresponding dividends for NASA's Human Space Flight Program or its Exploration Initiative that could be cited as rationales for the Administration's approach to NASA. Quite the opposite. In NASA's Exploration Program, the FY09 budget request provides no funds to reduce the looming gap in U.S. human access to space once the Shuttle is retired, in spite of widespread concern about this potential impact.

Indeed, given the low levels of reserves allocated to the Constellation Program over the next several years, it is hard to have confidence even in NASA's stated 2015 delivery date for the Crew Exploration Vehicle, a date five years after the Shuttle is retired.

In addition, NASA's Technology Program, something that should be the bedrock of R&D agency, has been progressively whittled away to the point it is largely an afterthought in the fiscal year 2009 budget request. And then there is the issue of the parting gifts left to the next Administration in the form of unfunded and underfunded requirements for the fiscal year 2009 NASA request.

For example, the five-year runout for the Shuttle program that accompanies the fiscal year 2009 request contains no money for Shuttle retirement and transition costs past 2010, even though NASA agrees that such funds will be required. Instead, any money needed for Shuttle retirement and transition costs will have to come out of the Exploration Account, which itself will already be facing large funding requirements in 2011, if the Lunar Program proceeds under NASA's planned schedule.

NASA's five-year budget contains no funding for the replacement of the Deep Space Network, even though NASA concedes it needs to happen if NASA is to have the capability to support all of the important space missions that will be occurred, occurring in the coming decades.

And, finally, I am concerned that the Administration's five-year budget request does not appear to allocate sufficient funding to meet the International Space Station's utilization and operations requirements after the Shuttle is retired. Indeed, NASA itself identifies ISS cargo and crew transportation as, and I quote, "The greatest program and budget risk" to the ISS program.

I could go on, but I hope my point is clear.

NASA and its Space and Aeronautics Research Programs are important, important to our standing in the world, important to our nation's scientific and technological future and foundation, and important to our quality of life.

Dr. Griffin and his team are dedicated and hardworking and represent some of the best and brightest in the Nation. Yet I am afraid that this budget and the vision for NASA that it represents fails them in several important ways. I hope that Dr. Griffin will help the Committee to address these issues both today and in the coming months. We need a sustainable and productive Space and Aeronautics Program for America, one that can be embraced by the next President and the next Congress. And that is what I want us to focus on this year as we work to reauthorize NASA.

With that, I want to welcome once again to the hearing today Dr. Griffin. I look forward to your testimony.

[The prepared statement of Chairman Gordon follows:]

PREPARED STATEMENT OF CHAIRMAN BART GORDON

Good morning. And welcome, Dr. Griffin.

Today's hearing will be Congress's first opportunity to review the President's Fiscal Year 2009 NASA budget request.

I expect that there will be much in that budget request that Members will want to discuss today and in subsequent Committee hearings.

Yet the FY09 budget request is not just a collection of funding levels and program descriptions.

Rather, it defines the Administration's priorities for NASA and its vision for what NASA should be doing in the coming years.

In that regard, this budget request—and Congress's disposition of it through the authorizing and appropriations process this year—will in large measure define the state of the space and aeronautics program that will be inherited by the next President.

So the stakes are high.

As many of you know, this year marks the 50th anniversary of the dawn of the U.S. space program and the establishment of NASA.

It also marks the 50th anniversary of the establishment of the Science and Technology Committee.

We—and NASA—were a direct result of the Soviet Sputnik launch, an event that sent shockwaves throughout the American government and the American public.

In fact, our Committee was established in part to help define an appropriate American response to Sputnik and to oversee America's fledgling space program.

Now—50 years after NASA's birth—I think that this committee needs to take a hard look at where NASA is headed, and whether or not the course that the current Administration has set NASA on is an appropriate one. . .and one that should be followed by the next Presidential Administration, whether it be Democratic or Republican.

We need to develop a congressional consensus on what NASA should be doing, and equally importantly, on what level of resources we this nation is willing to commit to NASA.

I thought we had achieved such a consensus in the *NASA Authorization Act of 2005,* which was passed by Congress and signed by the President.

Yet, the Administration's actions since that time unfortunately have not helped to maintain that consensus.

In particular, I believe that the Administration has to date failed to provide resources to NASA that are adequate for what it has asked NASA to do and what it agreed to in the Authorization Act.

And that's not just my opinion—if you review our Committee's hearings over the past several years, you will find bipartisan expressions of concern over the mismatch between NASA's tasks and the resources it's been given.

We see the impact of that approach to NASA throughout the budget request that we will be reviewing today.

Thus, we see an aeronautics program that continues on a downward path, despite clear congressional direction that echoes our belief that NASA's aeronautics R&D activities are critical to our competitiveness, the safety and efficiency of our aviation

system, and our quality of life—and despite clear evidence that our current air traffic control system is antiquated and under severe stress.

In the science arena, the situation is uncertain.

The good news is that NASA has at last taken steps—consistent with congressional urging and direction—to initiate new Earth science missions recommended by the National Academies in its recent Decadal Survey.

The bad news is that the funding for those new Earth science missions doesn't reflect any new commitment on the part of the Administration to enhancing NASA's overall science program.

Instead, funding for those missions will be provided by shifting money from other Earth science research activities as well as from other NASA science accounts in the coming years———

In short—a "musical chairs" approach to science funding.

Yet, the successive cuts to NASA's aeronautics portfolio and the uncertain outlook for the NASA science program have not resulted in any corresponding dividends for NASA's human space flight program or its exploration initiative that could be cited as rationales for the Administration's approach to NASA.

Quite the opposite. In NASA's exploration program, the FY09 budget request provides no funds to reduce the looming "gap" in U.S. human access to space once the Shuttle is retired, in spite of widespread concern about its potential impact.

Indeed, given the low levels of reserves allocated to the Constellation program over the next several years, it is hard to have confidence even in NASA's stated 2015 delivery date for the Crew Exploration Vehicle—a date five years *after* the Shuttle is retired.

In addition, NASA's technology program—something that should be the bedrock of an R&D agency—has been progressively whittled away to the point it is largely an afterthought in the FY09 budget request.

And then there is the issue of the "parting gifts" left to the next Administration in the form of unfunded and underfunded requirements in the FY09 NASA request.

For example, the five-year runout for the Shuttle program that accompanies the FY09 request contains no money for Shuttle retirement and transition costs past 2010, even though NASA agrees that such funds will be required.

Instead, any money needed for Shuttle retirement and transition costs will have to come out of the Exploration account—which itself will already be facing large new funding requirements in 2011 if the lunar program proceeds under NASA's planned schedule.

NASA's five-year budget contains no funding for the replacement of the Deep Space Network, even though NASA concedes it needs to happen if NASA is to have the capability to support all of the important space missions that will be occurring in the coming decades.

Finally, I am concerned that the Administration's five-year budget request does not appear to allocate sufficient funding to meet the International Space Station's utilization and operations requirements after the Shuttle is retired.

Indeed, NASA itself identifies ISS cargo and crew transportation as *"the greatest program and budget risk"* to the ISS program.

I could go on, but I hope my point is clear.

NASA and its space and aeronautics research programs are important—important to our standing in the world, important to our nation's scientific and technological foundation, and important to our quality of life.

Dr. Griffin and his team are dedicated and hardworking and represent some of the "best and brightest" in the Nation.

Yet I am afraid that this budget and the vision for NASA that it represents fails them in several important ways:

- It fails to fully exploit and nurture the impressive capabilities NASA has, and it fails to position NASA for a sustained and productive future.
- Instead I'm afraid that the Administration's budget and vision for NASA simply set the agency up for increased problems down the road.
- And most fundamentally, I have to ask whether it is credible to believe that we will be able to successfully carry out the human lunar program proposed by the Administration—while still maintaining a balanced NASA portfolio overall—if the NASA budgetary outlook doesn't improve.
- If it *isn't* credible, then we will need to determine whether there are any changes to be made that will still keep us moving forward in a balanced manner under the funding likely to be available to NASA.

I hope that Dr. Griffin will help the Committee to address these issues both today and in the coming months.

We need a sustainable and productive space and aeronautics program for America—one that can be embraced by the next President and the next Congress.

And that's what I want us to focus on this year as we work to reauthorize NASA.

With that, I again want to welcome you to today's hearing, Dr. Griffin, and I look forward to your testimony.

Chairman GORDON. And now the Chair recognizes Mr. Hall for an opening statement.

Mr. HALL. Thank you, Chairman. And my thanks, too, to NASA Administrator Mike Griffin, who is, I think, doing a superb job leading and managing the agency during this especially difficult time as NASA strives to complete the International Space Station, retire the Shuttle, and build a new human-rated launch system with an escape module.

The fiscal year 2009 NASA budget request continues to treat NASA favorably, especially when compared to other federal non-defense, discretionary programs. The fiscal year 2009 request proposes to increase NASA's funding by 1.8 percent compared to the last budget request, and the percentage is even higher when compared to the agency's fiscal year 2008 appropriations that was signed into law late last year.

Having said that, NASA is under enormous financial strain as it seeks to safely fly out Shuttle to its planned retirement in 2010, while concurrently paying for the design and construction of the new Constellation System and maintaining a balanced and robustly-funded science and aeronautics research portfolio. There are many in this room, myself among them, and in the space and science community, who would argue that more money is needed, but the broader federal budget realities make that possibility very difficult at this time.

Given the current budget profile, I believe Administrator Griffin is making the right choices. And I also believe it is vitally important that NASA continues to keep the Constellation Program on schedule to meet a 2015 launch date, if not sooner, and it is essential that we minimize, to the greatest degree possible, the amount of time that the U.S. goes without a manned space-launch capability. The prospect of being entirely reliant on our international partners for access to and from space is one that could have serious implications for America's space supremacy.

Our country needs the Constellation System. It will offer many new capabilities, most notably the ability to go beyond low Earth orbit on long duration missions, and it will also be a much safer vehicle, providing its crews a far more reliable means of escape in the event of a launch mishap.

I understand the need for phasing out Shuttle to free up resources for the development of the Constellation. But Congress should be mindful that this budget request, and particularly the Constellation program budget, is very, very lean, with little margin to cover unanticipated cost increases. If there are surprises, either Congress will have to provide the resources to address them, or be prepared to accept a gap of greater than five years. So I urge NASA, industry, and Congress to work together to ensure we get back to space as soon as possible.

Equally important is the need to maintain a skilled workforce to support Constellation. We cannot afford to lose these people such as we did between Apollo and Shuttle, and the longer the gap, the

greater the risk that we won't be able to retain the talented pool of engineers and technicians who currently support Shuttle. I guarantee that if our government's commitment to the Constellation Program begins to waver, or if the gap extends and we can't provide meaningful jobs that have clear promise for a predictable and robust launch schedule, we will lose these folks to other industries. The cost of time and money to train replacements will be enormous.

Finally, Dr. Griffin, knowing that you have a complex assembly mission now underway, and knowing of all the problems we face, the budget cutbacks, all of us greatly appreciate your willingness to take time out of a very, very busy schedule to appear before this committee and help us as you have done since you have occupied the position you are in. And I thank you.

Mr. Chairman, thank you, and I yield back to you.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF REPRESENTATIVE RALPH M. HALL

Thank you, Mr. Chairman, for calling this morning's hearing. And my thanks too, to NASA Administrator Mike Griffin, who is doing an absolutely superb job leading and managing the agency during this especially difficult time as NASA strives to complete the International Space Station, retire the Shuttle, and build a new, human-rated launch system.

The Fiscal Year 2009 NASA budget request continues to treat NASA favorably, especially when compared to other federal non-defense, discretionary programs. The FY09 request proposes to increase NASA's funding by 1.8 percent compared to the last budget request, and the percentage is even higher when compared to the agency's FY08 appropriations that was signed into law late last year.

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Mr. Griffin, knowing that you have a complex assembly mission now underway, all of us greatly appreciate your willingness to take time out of your busy schedule to appear before this committee. Thank you.

Chairman GORDON. Thank you, Mr. Hall.

Let me just quickly point out, many of you have been in this room many times before. We have not ostracized our former Chairmen. We are just in the process of trying to renovate some, and I think even Mr. Sensenbrenner's photograph may be recovered. We are not sure, though.

Mr. Udall, you are recognized.

Mr. UDALL. Thank you, Mr. Chairman. Good morning, Dr. Griffin. This hearing marks the beginning of our consideration of NASA's fiscal year 2009 budget request as well as providing us with an opportunity to engage with Dr. Griffin on a range of NASA-related issues.

NASA has been in the news in both positive and not-so-positive ways over the last year. In particular, I would note that our committee has had to ask the Government Accountability Office to analyze air safety data from the National Aviation Operations Monitoring Service pilot survey because NASA had refused to do so. We are all disappointed that we had to take that step, but rest assured that I intend to continue my oversight of this and other issues that need our subcommittee's attention.

Turning to the budget request at this point, it is clear that NASA faces significant challenges in carrying out the tasks that the Nation has asked it to assume, and those challenges have been made more difficult by the inadequate NASA budgets that have been sent over to the Hill from the White House over the past several years.

I had hoped that this budget request for NASA, which represents President Bush's last budget submission, would have reflected an intention by the Administration to finally address the impact of the previous shortfalls, yet in the main it does not.

The budget request has been described as a "stay-the-course" budget, and I do believe that that is an all-too-accurate description.

This budget continues the underfunding of the agency that has became painfully apparent in 2004, when the White House announced a major human and robotic exploration initiative, including returning American astronauts to the Moon by 2020, while making a virtue of the fact that it was only adding a billion dollars in new money to NASA's budget over the first five years of the Moon-Mars Initiative.

Since that time, it has sent over NASA budget requests that have consistently fallen short of what the Administration itself had said would be needed to establish or to enable NASA to carry out the initiative and its other core missions. Now, despite the fact that there is a projected five-year gap in the U.S.'s capability to get its astronauts into space after the Shuttle is retired, and despite the fact that the exploration initiative's Constellation Program currently has reserves of less than eight percent to cover any problems the development program might encounter over the next two years, the Administration has chosen not to request any additional funding for the Constellation Program in this latest budget request, de-

spite Congressional encouragement from both sides of the aisle to do so.

That is not a great message to send to NASA and the contractor teams that are working so hard to implement the President's initiative. Nor does it send a good signal to the next President, whoever it might be, that the Exploration Initiative is a priority worth continuing.

What are the other ways in which this NASA budget request stays the course?

Well, it continues the practice of marginalizing NASA's aeronautics R&D program, in spite of Congressional concern and direction to the contrary over the past several years. It is clear that the Nation's aviation system is under severe stress, and NASA research will be needed if we are to move successfully to a next generation air traffic management system while protecting the environment and maintaining safety. The Administration's current approach to NASA's aeronautics enterprise simply is not going to get the job done.

In the space operations arena, staying the course unfortunately means continuing the practice of leaving unfunded and underfunded liens for the next Administration to deal with, whether it be the costs of Shuttle transition and retirement, Deep Space Network replacement, or logistical support of the International Space Station, that is a troubling approach given the already over-constrained nature of NASA's out-year budgetary plan.

Here is one area, however, where "stay-the-course" was not followed, at least in part, and that is in NASA's Science Program. It appears that NASA did take steps in the fiscal year 2009 budget request to respond to concerns expressed by many in the science community and in Congress. The budget request contains new starts for high priority Earth Science missions recommended by the National Academies in its recent Decadal Survey, something I strongly support.

In addition, funding is allocated to augment NASA's Research and Analysis activities and to revitalize the sub-orbital research program, actions that will help train the next generation of space scientists and engineers. In addition, NASA has announced that it intends to undertake an ambitious series of new missions, including JDEM, a Solar Probe, an exoplanet detection mission, a Mars Sample Return Mission, a major Outer Planets Mission, as well as a significant increase in its lunar science initiative. It sounds very exciting and promising. However, the reality is that no new money is being requested for NASA's science account to carry out all these new initiatives beyond what had previously been assumed. It is going to affect money as simply being transferred between science accounts. That sounds a lot like the approach the Administration used to pay for the Exploration Initiative and Human Space Flight Programs, and we see how well that has worked.

In addition, the bulk of the funding requirements for these new initiatives occurs beyond this budget's planning horizon, in short, finding the necessary money will be the task of the next President and future Congresses. I hope that we will be able to undertake at least some of the worthwhile new initiatives being proposed. I am a strong supporter of a robust and exciting science program, but we

only have to recall the Administration's Project Prometheus and the JIMO mission to know that bold announcements don't always translate into real programs.

Well, I don't want to belabor the point, but it is clear that NASA faces a number of important challenges. I intend to work hard this year to develop legislation to reauthorize NASA, and today's hearing will provide important input to that effort.

Again, Dr. Griffin, welcome, and Mr. Chairman, I would yield back the balance of my time.

[The prepared statement of Mr. Udall follows:]

PREPARED STATEMENT OF CHAIRMAN MARK UDALL

Good morning.

I want to join my colleagues in welcoming Administrator Griffin to today's hearing.

This hearing marks the beginning of our consideration of NASA's fiscal year 2009 budget request, as well as providing us an opportunity to engage Dr. Griffin on a range of NASA-related issues.

Dr. Griffin, NASA has been in the news in both positive and not-so-positive ways over the last year. In particular, I would note that our Committee has had to ask the Government Accountability Office to analyze air safety data from the National Aviation Operations Monitoring Service (NAOMS) pilot survey because NASA had refused to do so.

I am disappointed that we had to take that step, but rest assured that I intend to continue my oversight of this and other issues that need our subcommittee's attention.

Turning now to the FY 2009 budget request, it is clear that NASA faces significant challenges in carrying out the tasks that the Nation has asked it to assume—and those challenges have been made all the more difficult by the inadequate NASA budgets that have been sent over to the Hill from the White House over the past several years.

I had hoped that this budget request for NASA—which represents President Bush's last budget submission—would have reflected an intention by the Administration to finally address the impact of the previous shortfalls, yet in the main it does not.

The budget request has been described as a "stay-the-course" budget.

Unfortunately, that is all too accurate a description.

Thus, this budget request continues the underfunding of the agency that became painfully apparent in 2004 when the White House announced a major human and robotic exploration initiative—including returning American astronauts to the Moon by 2020—while making a virtue of the fact that it was only adding a billion dollars in new money to NASA's budget over the first five years of the Moon-Mars initiative.

Since that time, it has sent over NASA budget requests that have consistently fallen short of what the Administration itself had said would be needed to enable NASA to carry out the exploration initiative and its other core missions.

Now, despite the fact that there is a projected five-year gap in the U.S.'s capability to get its astronauts into space after the Shuttle is retired. . .

. . .and despite the fact that the exploration initiative's Constellation program currently has reserves of less than eight percent to cover any problems the development program might encounter over the next two years. . .

. . .the Administration has chosen not to request any additional funding for the Constellation program in this latest budget request, despite congressional encouragement from both sides of the aisle to do so.

That's not a great message to send to the NASA and contractor teams that are working so hard to implement the President's initiative.

Nor does it send a good signal to the next President, whoever it might be, that the exploration initiative is a priority worth continuing.

What are the other ways in which this NASA budget request "stays the course"?

Well, it continues the practice of marginalizing NASA's aeronautics R&D program, in spite of congressional concern and direction to the contrary over the past several years.

It is clear that the Nation's aviation system is under severe stress, and NASA research will be needed if we are to move successfully to a next generation air traffic management system while protecting the environment and maintaining safety.

The Administration's current approach to NASA's aeronautics enterprise simply is not going to get the job done.

In the Space Operations arena, "staying the course" unfortunately means continuing the practice of leaving unfunded and underfunded liens for the next Administration to deal with—whether it be the costs of Shuttle transition and retirement, Deep Space Network replacement, or logistical support of the International Space Station.

That is a troubling approach, given the already over-constrained nature of NASA's outyear budgetary plan.

There is one area, however, where "stay-the-course" was not followed—at least in part—and that is in NASA's science program.

Thus, it appears that NASA did take steps in the FY09 budget request to attempt to respond to concerns expressed by many in the science community and in Congress.

Thus, the budget request contains new starts for high priority Earth Science missions recommended by the National Academies in its recent Decadal Survey, something I strongly support.

In addition, funding is allocated to augment NASA's Research and Analysis activities and to revitalize the sub-orbital research program—actions that will help train the next generation of space scientists and engineers.

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I hope that we *will* be able to undertake at least some of the worthwhile new initiatives being proposed—I am a strong supporter of a robust and exciting science program.

But we only have to recall the Administration's Project Prometheus and the JIMO mission to know that bold announcements don't always translate into real programs.

Well, I don't want to belabor the point: It is clear that NASA faces a number of important challenges.

I intend to work hard this year to develop legislation to reauthorize NASA, and today's hearing will provide important input to that effort.

Thank you, and I yield back the balance of my time.

Chairman GORDON. Mr. Feeney is recognized for an opening statement.

Mr. FEENEY. Thank you, Mr. Chairman, for holding this important hearing today. Between the Chairman, Ranking Member Hall, and Chairman Udall, I think they have outlined virtually all the major challenges facing NASA in the upcoming years to be considered by this committee.

I want to welcome the NASA Administrator, Michael Griffin, to our committee. We are fortunate for your leadership. I think that Mr. Hall said it very well. We are also fortunate for the retirement of the term "spiral development" from NASA's lexicon, and that is a step forward.

With the passage of time we run the risk of reverting back to pre-*Columbia* behavior. As the *Columbia* Accident Investigation Board observed, "NASA has usually failed to receive budgetary support consistent with its ambitions. The result is an organization straining to do too much with too little."

Both the legislative and the executive branch are susceptible of lapsing into this behavior.

On Capitol Hill, we are often eager to assign new missions to NASA. This compliment stems from NASA's incredible ability to perform the most difficult of assignments. Last November's solar array repair conducted by Astronaut Scott Parazynski proves a recent example of such seemingly effortless success in the face of an unexpected and daunting challenge.

But I agree with the notion that has been pointed out by both Chairman Gordon and Chairman Udall that at times the Administration has fallen short of funding its own priorities. But I would also point out that in the fiscal year 2007 Omnibus/Continuing Resolution, Congress appropriated to NASA $545 million less than the President's request with that reduction and then some coming from NASA's current and future Human Space Flight Programs. In the recently passed fiscal year 2008 Omnibus, Congress further reduced the agency's funding request through a $192.5 million rescission.

Today, the Administration's fiscal year 2009 budget request of $17.6 billion is 1.8 percent above last year's request. After factoring in inflation, NASA's resources are shrinking in real terms while the agency is charged with maintaining America's preeminence as a space-faring nation.

Maintaining such preeminence includes developing a new generation of human space flight vehicles to replace the Space Shuttle. As the *Columbia* Accident Investigation Board correctly noted, "It is the view of the Board that the previous attempts to develop a replacement vehicle for the aging Shuttle represented a failure of national leadership."

The Board went on to state, "Continued U.S. leadership in space is an important national objective. That leadership depends on a willingness to pay the costs of achieving it."

Administrator Griffin, I know you understand this truth, and you have been a great advocate in front of this committee and everywhere you go, pointing out to Americans the importance of the task laid out before you and the entire NASA team. The outstanding question is whether anyone else is listening.

Yield back the balance of my time.

[The prepared statement of Mr. Feeney follows:]

PREPARED STATEMENT OF REPRESENTATIVE TOM FEENEY

Thank you Mr. Chairman for holding today's hearing. I want to again welcome NASA Administrator Michael Griffin to our committee. We are fortunate for your leadership. We are also fortunate for the retirement of the term "spiral development" from NASA's lexicon.

With the passage of time, we run the risk of reverting back to pre-*Columbia* behavior. As the *Columbia* Accident Investigation Board observed:

> *NASA has usually failed to receive budgetary support consistent with its ambitions. The result. . .is an organization straining to do too much with too little.*

Both the legislative and executive branches are susceptible of lapsing into this behavior.

On Capitol Hill, we are often eager to assign new missions to NASA. This compliment stems from NASA's ability to perform the most difficult of assignments. Last November's solar array repair conducted by Astronaut Scott Parazynski provides a recent example of such seemingly effortless success in the face of an unexpected and daunting challenge.

But in the FY07 Omnibus/Continuing Resolution, Congress appropriated to NASA $545 million less than the President's request with that reduction—and then some—coming from NASA's current and future human space flight programs. In the recently passed FY08 Omnibus, Congress further reduced the agency's funding request through a $192.5 million rescission.

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Administrator Griffin, I know you understand this truth. The outstanding question is whether anyone else is listening.

Chairman GORDON. Thank you, Mr. Feeney. You know, although it may have been said different ways, I think it is clear that there is bipartisan agreement that the, what NASA is asked to be doing, is not properly matched with NASA's funding. And as we go through this year and as we try to develop a consensus reauthorization, we are going to have to deal with that reality.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Mr. Chairman, I would like to thank you for overseeing this budget hearing and thank Administrator Griffin for coming in today. As NASA begins to phase-out the Shuttle and enters into a new era of space exploration, it is imperative that Congress gives the Agency the resources necessary for success.

As Members of the Science and Technology Committee, we need to make sure that our children receive the best education possible and are particularly engaged in the sciences. I think this committee took an excellent step to assure our children's competitiveness in the science and technology fields by passing the COMPETES Act last year. NASA's space exploration programs and Shuttle missions have always been an integral component to engaging and exciting America's youth about the possibilities of science and research.

Mr. Chairman, we must assure that NASA has the right tools at its disposal to move beyond the Shuttle program, to return to the Moon, and to send our astronauts to Mars. I commend you for your stewardship of this committee and I look forward to learning about the plan for NASA's future. Thank you.

[The prepared statement of Mr. Lampson follows:]

PREPARED STATEMENT OF CHAIRMAN NICK LAMPSON

This year as we celebrate NASA's 50th anniversary, we are tackling new challenges for the next 50 years. But I fear that we will be caught behind the curve again as we were in 1957. Just two months ago the Associated Press reported that China will build a new family of rockets—a move that would boost China's capabilities to put satellites in space and voyage to frontiers previously accessible only to the United States. Japan put a probe into orbit around the Moon not too long ago and India is likely to join the rivalry soon, with plans to send its own lunar probe into space in April.

Although these programs are in the developmental stages—they signal the need to recommit to NASA—to the Vision—especially in the areas of science, exploration and aeronautic research and development.

I am most concerned about the nearly five-year space flight gap that will leave us without access to space and dependent on potentially unstable allies. And while your budget request states that the agency strives to bring Ares and Orion on-line

sooner, I fear that this gap will not only have economic and strategic consequences, but it will leave a vacuum of hope and inspiration for our children.

Martin Luther King discussed 'the fierce urgency of now'; we do not have the luxury of 'cooling off' or 'gradualism.' Our allies are challenging America's historic dominance in space and technology. They are challenging our very identity as pioneers.

Your budget provides $2.6 billion to purchase crew and cargo transportation services from potentially unstable allies. It is mind-boggling that we would spend our constituents' hard earned money in Russia or China and not here. $2.6 billion in the American space economy will help retain jobs, spur development, and encourage our youth to pursue math and science.

While I have long been a proponent of returning to the Moon and going to Mars, I believe it is not just about the destination. We all know the mission will spur technology and business and improve our quality of life. But there is also the unquantifiable return on our investment—and that is the excitement in children's eyes when they watch a launch or tell you that they want to be an astronaut.

We must shorten the gap and fulfill NASA's mission to conduct exploration and science in space. And launching the AMS will fulfill NASA's stated strategic goals of completing the ISS and using it for scientific research as well as the Vision's goal of greater space exploration. Thank you for being here today and I look forward to hearing your testimony.

[The prepared statement of Ms. Richardson follows:]

PREPARED STATEMENT OF REPRESENTATIVE LAURA RICHARDSON

Thank you Chairman Gordon for holding this important hearing today. I would also like to thank Dr. Griffin for taking the time to come and testify before the Committee this morning.

Since its inception in 1958, NASA has been the leading agency for American and global innovation. The launch of Explorer 1 on January 31, 1958 sparked a new era in American space exploration, technological innovation, and general interest in the Science, Technology, Engineering, and Mathematics fields. Maintaining that interest is a top priority for this committee, and I am confident that under the leadership of Chairman Gordon this committee is committed to preserving our nation's role as leaders in these fields. Certainly the "America COMPETES" legislation was a step in that direction. However we must be mindful that the budget request and subsequent appropriations process demonstrates more than anything else the level of commitment we provide to NASA.

Certainly the President's budget is not perfect but I am reluctantly encouraged by the overall increase, albeit a small one (1.8 percent over the FY08 request) in the proposed NASA budget. Any amount under last year's request would send the wrong message to NASA, an agency that is a source of national pride, not to mention an agency that is critical to our security efforts.

In an age of climate change, NASA's space science programs are critical to our understanding of planet Earth. This knowledge should have a direct impact on the policy decisions Congress makes as we move forward. In reviewing the President's budget I noticed a decrease in the space science programs and the Earth science programs so I am curious to know how NASA will work within these limited constraints.

In the area of Aeronautics research I am particularly concerned about aviation safety. I am particularly disturbed by the $25 million dollar reduction in NASA's budget for Airspace Systems. Our air traffic control system is antiquated, and the number of close calls on the runways of America's airports is growing. Consumer safety is always a top priority, and should never be compromised.

Finally I am troubled by the reduction in spending for NASA's education program. These programs are critical to increasing student interest in STEM fields, as well as developing diversity in these fields as well. I am interested in hearing what NASA plans to do in terms of outreach given these budget shortfalls.

In conclusion I want to commend NASA for all the good work they have done in the past. I lend my full support to the vital work they do everyday, and I know with Congress's full legislative and fiscal support they will continue to do good work.

Mr. Chairman I yield back my time.

[The prepared statement of Mr. Mitchell follows:]

PREPARED STATEMENT OF REPRESENTATIVE HARRY E. MITCHELL

Thank you, Mr. Chairman

NASA conducts vital research and development projects that help us learn about our surroundings.

Arizona State University, which is located in my district, is home to researchers who on many of these important NASA research projects.

To maintain America's competitiveness in science and technology, we must do more than merely keep up. We must lead, and commit ourselves to providing the resources necessary to keep us at the forefront of this kind of cutting edge research and development.

However, we must do so in a responsible manner. As Members of this committee, we have an obligation to exercise vigorous oversight, and ask tough questions to determine whether NASA is spending our federal dollars appropriately.

In October, we learned that NASA spent $11 million taxpayer dollars creating and conducting a survey of airline pilots on potential safety lapses in our nation's aviation network, before evading requests to release the data and refusing to stand behind the results of their own study.

For an agency with so many incredible accomplishments, this episode was certainly not its finest hour.

I certainly hope NASA is planning to be more careful with its future funding.

I look forward to hearing from Dr. Michael Griffin about NASA's proposed budget for Fiscal Year 2009 as well as the Operating Plan for Fiscal Year 2008.

I yield back.

Chairman GORDON. Now, thank you for listening to us pontificate, and Dr. Griffin, you are the one that we came here to hear today, and so now you are recognized.

STATEMENT OF DR. MICHAEL D. GRIFFIN, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Dr. GRIFFIN. Thank you, Chairman Gordon, Ranking Member Hall, Chairman Udall, Ranking Member Feeney, thank you very much. It is a pleasure to be here to discuss our budget request of $17.6 billion.

I want to highlight briefly the key features of this request, as well as to outline some areas where I will need the Committee's help, and then, of course, I want to answer your questions.

Last week Shuttle Atlantis delivered the European Columbus module to the International Space Station. Next up is Endeavor with the Japanese Kibo Logistics Module and the Canadian Dextre Manipulator Arm. After that Discovery delivers the Kibo Pressurized Module. With these flights we are honoring our nation's commitments to our international partners on station and meeting the most prominent milestones of the program.

Throughout four Presidential Administrations and over 20 Congressional votes authorizing tens of billions of dollars for its development, the Space Station remains an established feature of U.S. space policy. Its development is the largest task ever performed by the civilian agencies of the United States or our international partners. Such international partnerships are an integral part of our next steps out beyond low-Earth orbit toward what President Kennedy called this new ocean.

NASA is also taking the necessary steps to insure that space exploration is not simply all government, all the time. That is not the way the American West was developed, it is not how the greatest aviation system in the world was developed, and it ought not to be the way we develop the space frontier. Now is the time, and we are the people to make provisions for the contribution of the commercial space sector to our nation's overall space enterprise.

I believe that we can open the ISS to purchases by NASA of cargo and crew services developed and provided by commercial entrepreneurs in companies both large and small. For this purpose NASA's budget for '09 provides $173 million to leverage private investments in developing and demonstrating commercial space transportation capability.

Now, more than $2.6 billion is budgeted over the next five years to purchase cargo and crew services to support ISS operations. I would prefer to use as much of that as possible to purchase transportation services from American commercial companies rather than foreign entities.

However, while I believe that we will have U.S. commercial cargo transport services over the next few years, along with European and Japanese capability, it is my carefully-considered assessment that U.S. commercial crew transport vehicles will not likely be available by 2012. The prospective purveyors of such services, of course, claim otherwise and actually I wish them all possible success. No one hopes more than I that they are right and I am wrong. But our ability to sustain the station cannot be held hostage to hope.

Thus, given existing legislative restrictions, we will require explicit authorization by the Congress to make further extraordinary payments to Russia in order to provide crew transport to the station after 2011, for our astronauts, as well as those of our international partners to whom we have obligations.

Chairman Gordon and the Members of this committee, we will need your help with this. NASA needs this legislative authorization in 2008, because Russia requires 36 months of lead time to fabricate new Soyuz vehicles, and thus we need to finalize contractual agreements late this year if we expect to fly in the spring of 2012. For reference, NASA's current contract with Russia is worth about $780 million through 2011.

Now, I yield to no one in my belief that we need to minimize our dependence on the Russian Soyuz and protect against proliferation of weapons technology to our adversaries. It is dangerous to the United States to find itself dependent upon any external entity for a strategic capability, and space transportation is just that. I have been outspoken to the point of bluntness on this matter since being confirmed as Administrator in April of '05. I deplore the posture in which we find ourselves. It is unseemly in the extreme.

But today there is no other viable option. We are today reliant upon the Russian Soyuz for the substance of the International Space Station. Because this is fact and because I am guided by facts, I am glad that there are Russian services to buy and that Russia is a member of the Space Station Partnership. Their participation gives the United States time to develop U.S. cargo and crew transport systems while preserving the tens of billions of dollars we have invested in the ISS. But we will need your help not only in supporting our budget request but also with legislation authorizing NASA to purchase Russian crew transport for the ISS after 2011.

Some have suggested that this dilemma can be avoided by continuing to fly the Shuttle past the currently-planned retirement in 2010. I must be clear. We will remain dependent upon the Russian Soyuz System until a new commercial crew vehicle is qualified for

orbital flights of six months duration or until the Ares and Orion Systems are deployed because the Soyuz provides emergency crew return for all astronauts and cosmonauts on-board ISS. Delaying space Shuttle retirement does not solve that problem. In fact, it exacerbates it.

Money spent flying the Shuttle after 2010 is not available for Ares and Orion, which causes the gap between Shuttle retirement and deployment of new systems to grow, and with it the duration of dependence upon Russian systems.

Further, I share the view of the *Columbia* Accident Investigation Board to which Mr. Feeney referred earlier and which the *Columbia,* the CAIB referred to as an inescapable conclusion, quoting: "Because of the risk inherent in the original design of the Space Shuttle, because that design was based in many aspects on now obsolete technologies, because the Shuttle is now an aging system but still developmental, it is in the Nation's interest to replace the Shuttle as soon as possible as the primary means for transporting humans to and from Earth orbit." For this very reason the Board expressed dismay at how, "previous attempts to develop a replacement vehicle for the aging Shuttle represent a failure of national leadership," and called for a rigorous vehicle safety re-certification if the Shuttle were to be operated past 2010.

So that brings us to today, with the budgetary resources currently projected, especially for the critical development years of '09, and '10, we can realistically forecast Ares and Orion becoming available in early 2015. That said, the engineering and design teams for Orion and Ares in Houston, Huntsville, Cape Canaveral, Cleveland, Denver, Norfolk, California, and many, many other parts of the country are trying to beat that prediction. And so, again, I hope they are right and I am wrong, but leaving budgetary issues aside, especially those in the next couple of critical years, the earliest date we could possibly bring Ares and Orion on line would be in the fall of 2013. And that would cost additional money.

Now, the past several appropriation cycles have resulted in funding reductions for exploration in favor of other priorities. This has delayed our ability to bring these new systems on line. Because of the strategic importance of these first elements of the Constellation System, because of the unseemly posture of U.S. reliance on Russia for strategic capability, because American taxpayers are today paying Russian aerospace engineers to do work that should be done by Americans, because we will face growing competition from the advancing Chinese space program, and because we are in the middle of a difficult, once-in-a-generation transition from the Shuttle to a new human space flight system, I ask that Congress fully fund NASA's exploration effort. It is critical to our nation's leadership in space.

Now, despite the demands of this once-in-a-generation transition, the budget request provides an appropriate balance between human space flight, Earth and space science, and aeronautics research. NASA is operating 55 science missions today, hearing into the farthest reaches of the universe, digging among the rocks of Mars, monitoring our sun's behavior, and conducting research on the causes and affects of global warming on our planet.

The '09 budget provides $910 million over the next five years for high-priority Earth science missions as recently defined by the National Academy of Sciences. Our nation's investment in Earth science is paying dividends, and we are shifting funds from other science disciplines because of the recognition on the part of the public and policy-makers of the value of global warming research coming from NASA's Earth scientists.

NASA's satellites supply more global climate change data than those of any other organization in the world, and we remain the largest contributor to the Interagency Climate Change Science Program. We plan to launch 14 new science missions in the next two years, and in late August or early September we plan to launch the much-anticipated final Space Shuttle servicing mission for Hubble. As these missions are completed, funds become available for new missions.

That said, I must report to you per the *NASA Authorization Act of 2005,* major program reporting requirements, that NASA's current development cost estimate of about $325 million for the Glory Earth Science Mission has exceeded the 30 percent threshold and cost growth. Thus, it will require explicit authorization in the next 18 months to continue. Glory is a high-priority mission for Earth science, and I hope you will allow it to continue.

In aeronautics we are aligning our research efforts with the many other agencies in the Federal Government also conducting such research. In partnership with a number of agencies of the JPDO we are conducting fundamental research on environmental safety and capacity challenges facing our nation's air transportation system. We are developing world-class aeronautics expertise, and we are closely coordinating the use of our research and test facilities with that of other federal agencies. We are also pursuing innovative partnerships with commercial companies to better leverage private investment toward national goals in aeronautics and other areas.

In conclusion, Chairman Gordon, Ranking Member Hall, I want to thank this Committee for its time and attention. We have many challenges, but I believe the greatest challenge we face is to maintain a unified purpose throughout the difficult transition from Shuttle to Constellation. Space exploration is not for the faint of heart nor for those who are easily distracted.

I recently spoke at Calvin College in Grand Rapids where Congressman Vern Ehlers taught physics for 17 years. In that speech I explained how the leaders of the House Science and Technology Committee, whose pictures used to adorn these walls, spoke passionately of the need for a unifying space policy in the wake of the Space Shuttle *Columbia* loss. The President heeded that advice in issuing the *Vision for Exploration,* which after almost two years of informed debate, culminated in the NASA Authorization Act of '05.

That legislation, enacted with strong bipartisan majority, codified into law the unifying vision called for by the *Columbia* Accident Investigation Board. I personally believe that it is the best civil space policy this nation has had since the time of Apollo. It provides a unified direction as to where we are headed, a sense of purpose, and a lasting legacy for the crew of *Columbia* and those among our nation's leaders who recognize the strategic importance of space ex-

ploration. Most importantly, it is the law of the land, and today we at NASA are turning that law into concerted action.

Former Chairman of the House Science Committee, Congressman Bob Walker from Pennsylvania, framed the issue perfectly in a speech shortly after *Columbia*: "For every generation choices are made that lead to greatness or to mediocrity." So it is all a matter of what each generation in its time here on Earth chooses to do with its energy, resources, and intellect.

I want to thank this committee for having chosen a path that leads to greatness, and I ask for your help in staying that course.

Thank you.

[The prepared statement of Dr. Griffin follows:]

PREPARED STATEMENT OF MICHAEL D. GRIFFIN

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear today to discuss the President's FY 2009 budget request for NASA. The President's budget request for NASA is $17.6 billion, a 2.9 percent increase over the net budget authority enacted for 2008, along with a steady, five-year runout commensurate with inflation. This increase demonstrates the President's commitment to funding the balanced priorities he set forth for the Agency in space exploration, Earth and space science, and aeronautics research. We are making steady progress in achieving these goals. I ask for your continued support as you consider the President's FY 2009 budget request for NASA.

When I testified before this committee last year, I spoke about the Administration's balanced priorities for our nation's civil space and aeronautics research goals as set forth by the *NASA Authorization Act of 2005* (P.L. 109–155) and the *Vision for Space Exploration.* NASA's mandate is clear, and the *NASA Authorization Act of 2005,* as well as the level of funding appropriated to NASA in FY 2008, tells me that Congress broadly endorses the balanced set of programs the Agency has put forward in this era of limited budget growth.

I have said this in other forums, but it warrants repeating here: at present funding levels, NASA's budget is sufficient to support a variety of excellent space programs, but it cannot support all of the potential programs we could execute. No plan or level of funding can fully satisfy all the many constituencies we have. Balanced choices must be made. But they cannot continually be remade and revisited if there is to be steady progress toward our common, defined objectives.

As the *Columbia* Accident Investigation Board noted, and as stakeholders acknowledged in ensuing policy debates, it would have been far worse to continue with the prior lack of strategic direction for human space flight, to continue dithering and debating and inevitably widening the gap between Shuttle retirement and the availability of new systems. Until and unless the Congress provides new and different authorization for NASA, the law of the land specifies that we will complete the International Space Station, retire the Shuttle, design and build a new space flight architecture, return to the Moon in a manner supporting a "sustained human presence," and prepare the way to Mars.

We are doing those things as quickly and efficiently as possible. System designs for the early elements have been completed, contracts have been let, and consistently solid progress is being made with a minimum of unexpected difficulty. True, the progress might be slower than all of us would prefer, but applying resources in the right direction, irrespective of pace, is always productive—and we are doing that. The Ares I Crew Launch Vehicle and the Orion Crew Exploration Vehicle, as they are presently taking form, are the building blocks for any American future beyond Low Earth Orbit (LEO).

Given that this endeavor will be our first step beyond LEO for crewed spacecraft since 1972, I believe that bypassing the Moon to venture directly into deep space—a proposal some have suggested revisiting—poses unacceptable risk. Returning to the Moon and consolidating the gains to be made thereby will set us properly on the path toward Mars. I believe that the *NASA Authorization Act of 2005* remains the finest policy framework for United States civil space activities that I have seen in forty years. And, I thank this committee for its leadership role in crafting this legislation. I ask for your continued support and leadership as we progress toward achieving the worthy National objectives laid out in the Act.

In the invitation to testify today, you asked that I be prepared to discuss NASA's initial FY 2008 Operating Plan, submitted to the Committee on February 1, 2008.

I would be pleased to respond to any questions you may have on the details. In summary, the initial Operating Plan provides aggregate funding of $17.3 billion, at the level of the President's FY 2008 request. Pursuant to the rescission of $192.5 million in NASA unobligated balances in the *Consolidated Appropriations Act, 2008* (P.L. 110–161), aggregate funding in NASA's FY 2007 Operating Plan is reduced by $185.2 million, and prior year balances are reduced by $7.2 million. Implementation of direction in P.L. 110–161 has resulted in a total reduction of $620.9 million in planned NASA activities, consisting of the rescission of $192.5 million, offsets for programmatic augmentations totaling $345.2 million, and site-specific Congressional interest items totaling $83.2 million. Finally, in accordance with Congressional direction, NASA has established seven Agency appropriations accounts in the FY 2009 budget request. As a result, the budgets for NASA's programs and projects are requested only in terms of direct costs, not the additional indirect costs associated with operating the Agency's field Centers, safety and mission success and Agency management and operations. The direct budgets will continue to reflect labor, travel, and procurement costs associated with each program and project. The indirect costs are now budgeted solely within the Cross Agency Support account, and not in the NASA programs and projects. We will strive to ensure that these changes are transparent to our stakeholders.

I am appreciative of the action by the Committees on Appropriations and Congress in providing regular FY 2008 appropriations for the Agency at the level of the President's request, including essentially full funding for the Orion, the Ares I, the Space Shuttle, and the Space Station. This total FY 2008 appropriations level, with some adjustments within the total, will enable NASA to meet critical priorities in accordance with the direction from the Congress and the President.

Highlights of the NASA FY 2009 Budget Request

I am pleased to report that the FY 2009 budget represents a substantial step forward in responding to the recommendations of the National Research Council's (NRC) first decadal survey of Earth Science, released in January 2007. The five-year budget runout requests $910 million for priorities enumerated in the report. Funding will support development of two Decadal Survey new mission priorities—the Soil Moisture Active/Passive (SMAP) mission scheduled to launch as early as 2012, and the Ice, Clouds, land Elevation Satellite II (ICESat II) scheduled to launch in 2015—as well as formulation of three additional decadal survey missions.

Working closely with NOAA, we also are making significant progress toward restoring climate sensors that had been removed from the tri-agency National Polar-Orbiting Operational Environmental Satellite System (NPOESS) in 2006. The FY 2009 budget request of $74 million for NOAA supports the addition of a Clouds and the Earth's Radiant Energy System (CERES) instrument onto NASA's NPOESS Preparatory Project (NPP) satellite, set to launch in 2010; instrument development and ongoing analyses to identify a suitable satellite platform for hosting the Total Solar Irradiance Sensor (TSIS); and development of climate data records. These actions, which will be implemented through close coordination between NASA and NOAA, come in addition to the inclusion of the Ozone Mapping and Profiler Suite (OMPS)-Limb sensor on the NPP satellite that was announced earlier in 2007.

The Agency's FY 2009 budget request also reflects a number of exciting developments in the space sciences, including an increase in the number of new missions, a new initiative in lunar science and initiation of plans for high priority missions in Astrophysics and Planetary Exploration. The FY 2009 request includes an increase of $344 million over five years for Lunar Science in order to better understand our Moon. NASA's Science mission directorate, with support from the Exploration directorate is developing two small lunar landers, and the Science Mission Directorate is initiating a series of new and exciting missions headed to the Moon over the next decade. Meanwhile, we are focusing our Mars program after 2013 on a Mars sample return mission to launch by 2020, and have identified funds to initiate development of an outer planets flagship mission to be selected in October of this year for launch by 2017. The budget also significantly increases Research and Analysis funds in the space sciences to gain better value from the missions we are flying, and so too, it increases the funding and, therefore, the flight rate of our suborbital rocket and balloon research programs in the space sciences.

Our Aeronautics Research portfolio is positioned to address the challenges facing the Next Generation Air Transportation System, while also developing world-class aeronautics expertise and capabilities. Research is aligned with the National Plan for Aeronautics Research and Development and Related Infrastructure, approved by the President in December 2007. In FY 2009, we will conduct a key test to advance our understanding of aircraft aging and durability, and develop algorithms to optimize the use of crowded airspace and airports. We will continue work on blended-

wing-body aircraft, which may reduce fuel consumption and emissions, as well as aircraft noise. Additionally, NASA's Aeronautics Research Mission Directorate continues to strengthen partnerships with academia, industry, and other government agencies to accomplish its strategic goals.

NASA's commitment to its exploration objectives is clearly reflected in the FY 2009 budget request. As assembly of the Space Station nears completion, NASA will increasingly focus its efforts on continuing the development of the Orion Crew Exploration Vehicle and Ares I Crew Launch Vehicle. This budget request maintains Orion initial operational capability in March 2015, and full operational capability in FY 2016, though we are striving to bring this new vehicle on line sooner. In FY 2008, we will see the completion of the formulation phase for major elements of the Constellation program; both Orion and Ares I will undergo their preliminary design reviews. We will conduct the first Ares ascent development flight test with the Ares I–X in the Spring of 2009, and we will continue to conduct research and develop and test technologies through the Advanced Capabilities Human Research and Exploration Technology Development Program. The Lunar Reconnaissance Orbiter (LRO)/Lunar Crater Observation Sensing Satellite (LCROSS), an important part of NASA's lunar exploration strategy, is on track for launch at the beginning of FY 2009. The Agency is also requesting $173 million to provide incentives for entrepreneurs—from big companies or small ones—to develop commercial transport capabilities to support the International Space Station. With more than $2.6 billion in NASA funds available over the next five years to purchase cargo and crew services to support Space Station operations, our objective and strong preference is to use these funds to purchase these services from American commercial companies wherever possible.

While I would prefer that the United States have domestic alternatives to purchasing crew transport services from Russia, I am glad that the Russians are our partners and have such capabilities, because the consequences if they were not available are far worse. If NASA astronauts were not on-board the Space Station, our National Laboratory in space simply would not survive. If there is no Space Station, there is no market for the commercial providers we are trying to help bring into existence, and our international partnership would simply fall apart. So in order to keep these objectives viable, NASA may need to obtain additional crew and cargo transport services from our international partners if U.S. commercial services are not yet demonstrated and available.

In the area of Space Operations, NASA's FY 2009 budget request will allow us to continue to expand the Space Station, complete the supporting truss structure and solar arrays, and deliver the final component of the Japanese laboratory. This will round out the set of three space laboratories aboard the Station, with one each from the U.S., Europe, and Japan. In addition, FY 2009 will mark another milestone for the Space Station Program—for the first time, the Station will be able to support a full-time crew of six astronauts. With three major scientific facilities available to them, these larger crews will be busy as Station kicks off a new era in microgravity research aboard this National Laboratory in orbit. Critical to these achievements, the Space Shuttle is scheduled to fly four times in FY 2009. During that year, NASA also plans to launch payloads on eight expendable launch vehicles. FY 2009 will also see the consolidation of the Deep Space, Near-Earth, and Space Communications networks into a unified Space Communications and Navigation (SCaN) architecture within the Space Operations Mission Directorate.

NASA is continuing to transition from the Space Shuttle to new Exploration systems, and will need a complement of critical tools and authorities necessary for the transformed Agency to execute its mission. This transition is the largest and most daunting since the end of the Apollo program and the beginning of the Space Shuttle program. It dictates that we obtain the authorities needed to ensure sufficient support in the future. We hope to discuss the details of these legislative requests with Members of Congress in the weeks ahead.

The remainder of my testimony outlines the FY 2009 budget request for NASA in greater detail.

Science Mission Directorate

In 2007, NASA successfully launched four new orbital and planetary science missions (THEMIS, AIM, Phoenix, and Dawn), almost 20 sub-orbital science missions, and two major airborne Earth science campaigns. This past year also saw the first test flights of the Stratospheric Observatory for Infrared Astronomy (SOFIA) 747 airborne infrared observatory, as well as the provision of rapid-response airborne remote sensing aid to the California wildfire emergencies. In addition, 2007 was a year of remarkable scientific discovery about the Earth, the Sun, the planets and the universe. For example, data from the Ice, Cloud, and land Elevation Satellite

(ICESat), the Gravity Recovery and Climate Experiment (GRACE), and other satellites have provided dramatic new insights on ice sheet changes in Greenland and Antarctica. The Solar TErrestrial RElations Observatory (STEREO) satellites (A and B) have provided the first three dimensional images of the sun and the structures of the heliosphere. These new 3–D views, along with unprecedented observations from Hinode (Solar-B), NASA's Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission, and the Aeronomy of Ice in the Mesosphere (AIM) satellite are revolutionizing knowledge of the variable Sun and its interactions with the Earth. Also, the Cassini spacecraft radar imagery of Titan revealed large lakes of methane in Titan's North polar region, indicating a hydrological cycle. Finally, a new map provides the best evidence to date that normal matter, largely in the form of galaxies, accumulates along the densest concentrations of dark matter. Mapping dark matter's distribution in space and time is fundamental to understanding how galaxies grew and clustered over billions of years.

NASA's FY 2009 budget request provides $4.44 billion for the Agency's Science portfolio to study the Earth, our Sun and its heliosphere, our solar system, and the Universe. This funding enables NASA's Science Mission Directorate (SMD) to start major new missions, to increase research and analysis funding, and to operate and provide ground support for 55 operating science missions, including 13 Earth science mission extensions. It provides support for over 3,000 current operating research and analysis grants, while continuing to develop high priority missions in Earth Science, Heliophysics, Planetary Science and Astrophysics, consistent with the priorities established by the NRC's decadal surveys.

Pursuant to requirements of the *NASA Authorization Act of 2005* (P.L. 109–555), and consistent with the latest notification provided to the Committee on February 11, 2008, NASA is in the process of producing more detailed reports on budget adjustments and schedule changes which have occurred since NASA submitted its FY 2006 and FY 2007 Baseline Reports under the Act. Detailed reports are in work and planned for submission to the Committee in March 2008 on Aquarius, Glory, Herschel, Kepler, NPP, and OCO. In addition, Glory has exceeded the 30 percent cost threshold triggering additional requirements as provided in the Act. Initial notifications are now in work under the processes established by act the Act for schedule changes for GLAST and SOFIA.

The FY 2009 budget request for Earth Science provides $1.37 billion to help us better understand the Earth's atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere as a single connected system. In addition to 14 operating missions, the request includes funding for seven missions in development. The Landsat Data Continuity Mission and Ocean Surface Topography Mission (to launch in 2008) continue the decades-long time series of land cover change and ocean surface height data, respectively. Glory targets the impact of aerosols on climate. The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) paves the way for the future national weather system and continues essential measurements from the NASA Earth Observing System (EOS), Aquarius, and the Orbiting Carbon Observatory (OCO), set to launch in 2008. Aquarius and OCO will make the first-ever global measurements of ocean surface salinity and atmospheric carbon dioxide, respectively. The request specifically increases funding for OCO and the Aquarius missions to maintain development schedules. The Global Precipitation Measurement (GPM) mission will extend the rainfall measurements made by the Tropical Rainfall Measurement Mission (TRMM) to the global scale. The request retains the GPM core mission launch readiness date.

The budget request responds to the Earth Science Decadal Survey by establishing a funding wedge of $910.0 million over the budget runout to initiate five new Earth Decadal Survey missions for launch by 2020, while continuing to implement seven precursor missions for launch between 2008 and 2013. NASA will continue to contribute to the President's Climate Change Research Initiative by collecting data sets and developing predictive capabilities that will enable advanced assessments of the causes and consequences of global climate change.

The Heliophysics budget request of $577.3 million will support missions to understand the Sun and its effects on Earth, the solar system, and the space environmental conditions that explorers will experience, and to demonstrate technologies that can improve future operational systems. The request increases budgets for Sounding Rockets, Research Range, and Research and Analysis to achieve a more robust level of small payload opportunities. In addition to supporting 16 currently operational missions, the request supports the Interstellar Boundary Explorer (IBEX) mission focused on the detection of the very edge of our solar system and the Coupled ion-Neural Dynamics Investigation (CINDI) "Mission of Opportunity" that will provide new insight on the Earth's ionospheric structure, both of which are

planned for launch in 2008. In early FY 2009, the Solar Dynamics Observatory (SDO) to study the Sun's magnetic field is planned for launch, and the Geospace Radiation Belt Storm Probes (RBSP) mission will begin development. RBSP will improve our understanding of how the Earth's radiation belts are formed and how solar output modifies the Earth's Van Allen radiation belts. Further, the five-year budget funds a new Solar Probe mission which has long been sought by the U.S. scientific community and is recommended highly in the most recent Heliophysics decadal survey.

The Planetary Science budget provides $1.33 billion to advance scientific knowledge of the solar system, search for evidence of life, and to prepare for human exploration. The budget supports an array of eight currently operating spacecraft and rovers traveling to or now studying Mercury, Mars, the Asteroid Belt, Saturn, and Pluto, in addition to a series of instrument missions of opportunity. The budget request augments Lunar Science to include a series of small robotic lunar satellites to begin development in FY 2009 and initiates an outer planets flagship mission, planned for launch in 2016 or 2017. The request includes continuation of funds for all five of NASA's operating Mars missions, the development of a Mars Science Laboratory in 2009 and a Mars Scout mission in 2013. The Mars Program is redirected to focus on the Mars Sample Return mission after the Scout 2013 opportunity, while expanding U.S. participation on the ESA/ExoMars mission by selecting two instrument Missions of Opportunity for study and technology development. With the New Horizons spacecraft continuing on its way to Pluto, the request realigns the New Frontiers Program's Juno Mission to Jupiter to be consistent with a 2011 launch date, and funds initiation of the next New Frontiers mission. An open competitive solicitation for the next mission is planned for release near the end of this calendar year. The request continues support for the operating Discovery mission and for the development of the new Gravity Recovery and Interior Laboratory (GRAIL) Discovery mission, the latter of which will use high-quality gravity field mapping of the Moon to determine the Moon's interior structure.

The Astrophysics budget provides $1.16 billion to search for answers to fundamental questions about how the universe works, how we got here, and whether we are alone. The request supports a restart of the Nuclear Spectroscopic Telescope Array (NuSTAR) Small Explorer with a launch date of no-earlier-than 2011, increases funding for sounding rocket payloads, balloon payloads, detector technology and theory, and initiates the Joint Dark Energy Mission (JDEM) in FY 2009. The Astrophysics suite of operating missions includes three Great Observatories (Hubble Space Telescope, Chandra X–Ray Observatory and the Spitzer Space Telescope), which have helped astronomers unravel the mysteries of the cosmos. The request will support the Gamma-ray Large Area Space Telescope (GLAST), which is now planned for launch in May, 2008, to begin a five-year mission mapping the gamma-ray sky and investigating gamma-ray bursts. It also provides funding for the Kepler telescope, which is planned for launch in February 2009, to detect planets in the "habitable zone" around other stars. SOFIA will begin science operations in 2009, significantly earlier than previously planned. The request supports development of the Wide-field Infrared Survey Explorer (WISE), which will conduct an all-sky survey, and the James Webb Space Telescope, which will explore the mysterious epoch when the first luminous objects in the universe came into being after the Big Bang.

Aeronautics Research Mission Directorate

In 2007, the Aeronautics Research Mission Directorate (ARMD) continued to pursue high-quality, innovative, and cutting-edge research that develops revolutionary tools, concepts, and technologies to enable a safer, more flexible, environmentally friendly, and more efficient national air transportation system. ARMD's research also plays a vital role in supporting NASA's space exploration activities. ARMD's program content and direction is consistent with the National Aeronautics Research and Development Policy, as well as the follow-on National Plan for Aeronautics Research and Development and Related Infrastructure that the President approved on December 21, 2007.

A primary goal across all of the programs in ARMD is to establish strong partnerships with industry, academia, and other government agencies in order to enable significant advancement in our nation's aeronautical expertise. NASA has put many mechanisms in place to engage academia and industry, including industry working groups and technical interchange meetings at the program and project level, Space Act Agreements for cooperative partnerships, and the NASA Research Announcement (NRA) process that provides for full and open competition for the best and most promising research ideas.

ARMD has established over 35 Space Act Agreements with industry partners and more are in the works. We have ensured that all Space Act Agreements are nego-

tiated so that results of collaborations will be broadly disseminated. To date, NASA has selected 346 proposals for negotiation of award through the NRA process from more than 70 different universities and 60 different companies and non-profits. NASA investment in NRAs will increase steadily from FY 2009 ($72 million) through FY 2013 ($100 million).

We have also strengthened our partnerships with other government agencies. For example, NASA and the Joint Planning and Development Office (JPDO) have established quarterly reviews to ensure close coordination, and NASA participates in all major JPDO planning activities. In addition, NASA and the Federal Aviation Administration have developed a joint program plan for the Aviation Safety Information Analysis and Sharing (ASIAS) effort with well defined roles and responsibilities. Also, NASA and the

U.S. Air Force have established an Executive Research Council that meets at least twice a year to ensure close coordination and collaboration. Lastly, NASA and the Army have signed a Memorandum of Understanding to coordinate research efforts on rotorcraft.

In FY 2009, the President's budget for NASA requests $446.5 million for Aeronautics Research. ARMD is directly addressing the fundamental research challenges that must be overcome in order to enable the JPDO vision for the Next Generation Air Transportation System (NextGen).

NASA's Airspace Systems Program has partnered with the JPDO to help develop concepts, capabilities and technologies that will lead to significant enhancements in the capacity, efficiency and flexibility of the National Airspace System. In FY 2009, NASA's budget request will provide $74.6 million for the Airspace Systems Program to conduct trajectory analyses for service-provider-based automated separation assurance with time-based metering in an environment with two to three times capacity and with delay and separation comparable to or better than that achieved today. In addition, the Airspace Systems Program will develop algorithms to generate robust, optimized solutions for airport surface traffic planning and control. These surface models will be developed as a basis for the optimized use of super-density airports, integrated airport clusters, and terminals where demand for runways is high.

NASA's Fundamental Aeronautics Program conducts research in all aeronautics disciplines that enable the design of vehicles that fly through any atmosphere at any speed. The FY 2009 budget request, amounting to $235.4 million, will enable significant advances in the Hypersonics, Supersonics, Subsonic Fixed Wing, and Subsonic Rotary Wing projects that make up the Fundamental Aeronautics Program. These projects focus on creating innovative solutions for the technical challenges of the future: increasing performance (range, speed, payload, fuel efficiency) while meeting stringent noise and emissions constraints; alleviating environmental and congestion problems through the use of new aircraft and rotorcraft concepts; and facilitating access to space and re-entry into planetary atmospheres. A wide variety of cross-cutting research topics are being pursued across the speed regimes with emphasis on physics-based multi-disciplinary analysis and design, aerothermodynamics, materials and structures, propulsion, aero-servo-elasticity, thermal protection systems, advanced control methods, and computational and experimental techniques.

The FY 2009 budget request for NASA's Aviation Safety Program is $62.6 million. The four projects within the Program (Integrated Intelligent Flight Deck, Integrated Resilient Aircraft Control, Aircraft Aging and Durability, and Integrated Vehicle Health Management) will develop cutting-edge tools, methods, and technologies with close coordination among them to improve the intrinsic safety attributes of current and future aircraft that will operate in the NextGen. In FY 2009, the Program will demonstrate aircraft engine safety and reliability improvements using advanced sensing technologies and new methods for modeling engine gas flow characteristics. In addition, ballistic tests will be used to study the effect of aging on the impact resiliency of composite fan-blade containment structures for aircraft engines.

Multiple flight and simulation tests will evaluate technologies to protect aircraft during hazardous situations. For example, simulations will evaluate technologies enabling aircraft to land safely even when flight control surfaces are partially damaged or malfunctioning, and flight tests will examine forward-looking, multi-frequency radar systems for early detection of potential hazardous icing.

Finally, NASA's Aeronautics Test Program (ATP) will continue to safeguard the strategic availability of a critical suite of aeronautics test facilities that are deemed necessary to meet Agency and national aeronautics needs. The FY 2009 budget request for the ATP is $73.9 million, which will enable strategic utilization, operations, maintenance, and investment decisions for major wind tunnel/ground test facilities at Ames Research Center in California, Glenn Research Center in Ohio, and Langley Research Center in Virginia, and will support specific aircraft and test bed

aircraft at Dryden Flight Research Center, also in California. ARMD has established the National Partnership for Aeronautical Testing with the Department of Defense to pursue a coordinated approach to managing DOD–NASA aeronautical testing facilities. In FY 2009, ATP will continue to reduce the deferred maintenance associated with its facilities and will also invest in new test technologies ensuring a healthy set of facilities and the new capabilities needed for future programs. In addition, ATP plans to continue off-setting the user rates for its facilities through the funding of a portion of the indirect costs resulting in competitive prices. Simultaneously, the Program will continue to move toward a long-term strategic approach that aligns the NASA and DOD facilities to meet future requirements with the right mix of facilities and appropriate investments in facility capability.

Exploration Systems Mission Directorate

In 2007, the Exploration Systems Mission Directorate (ESMD) delivered as promised and will continue to do so in 2008. Major development work is underway; contracts are in place, and our future Exploration plan is executable. By the end of 2008, ESMD will see its first spacecraft launched from the NASA Kennedy Space Center, Florida. This Lunar Reconnaissance Orbiter (LRO) and the Lunar Crater Observation Sensing Satellite (LCROSS) will help NASA scout for potential lunar landing and outpost sites. Additionally, in 2008, NASA will continue to plan how best to transition any needed Shuttle workforce and infrastructure to the Constellation program.

The FY 2009 budget request of $3.5 billion for Exploration will support continued development of new U.S. human space flight capabilities and supporting research and technologies, and will enable sustained and affordable human space exploration after the Space Shuttle is retired at the end of FY 2010. The budget request provides stable funding to allow NASA to continue developing our next-generation U.S. human space flight vehicles while also providing research and developing technologies for the longer-term development of a sustained human presence on the Moon. Budget stability in FY 2009 is crucial to maintaining a March 2015 Initial Operational Capability for the Orion Crew Exploration Vehicle and Ares I Crew Launch Vehicle. There is minimum flexibility through 2010, so Congressional support for budget stability is critical. Additionally, ESMD will continue to work with other nations and the commercial sector to coordinate planning, leverage investment, and identify opportunities for specific collaboration on lunar data collection and lunar surface activities.

The FY 2009 budget request for Constellation Systems Program is approximately $3.0 billion. The Constellation program includes funding for the Orion and Ares, as well as for ground operations, mission operations, and extra-vehicular activity projects and a dedicated in-house effort for systems engineering and integration. Last year, the Constellation program made great strides and it will continue to do so in 2008. We have tested real hardware; we have tested landing systems; and we have logged thousands of hours in wind tunnels. So far, NASA engineers have conducted almost 4,000 hours of wind tunnel testing on sub-scale models of the Ares I to simulate how the current vehicle design performs in flight. These wind tunnel tests, as well as NASA's first scheduled demonstration test flight for Ares I, known as Ares IX, are scheduled for spring 2009 and will lay the ground work for maturing the Ares I final design.

Constellation has an integrated schedule and we are meeting our early milestones. In fact, all major elements of the Orion and Ares vehicles were placed under contract by the end of 2007. Currently, NASA has civil servants and contractors on board for the Constellation program serving at all ten Agency Centers, as well as in more than 20 states. In 2008, NASA will continue efforts to define the specific work the Agency's Centers will perform in order to enable astronauts to explore the Moon. Preliminary work assignments covering elements of the Altair human lunar lander and lunar surface operations, as well as the Ares V, were announced in October 2007.

During 2007, ESMD completed a series of key project review milestones, including a System Definition Review for the Orion project in August and for the Ares I project in October. During these reviews, each project examined how its proposed requirements impact engineering decisions for the functional elements of the system. The Orion and Ares I teams are currently assessing design concepts, and are moving toward finalized reference designs that meets their requirements. This reference configuration will be the starting point for the design analysis cycle that leads to Preliminary Design Reviews for the Orion and Ares I projects, in turn leading to an integrated stack review by the end of December 2008. A Preliminary Design Review is a crucial milestone, during which the overall program verifies that

the preliminary design meets all requirements within acceptable risk limits and within the cost and schedule constraints.

In FY 2009, NASA is requesting $173 million for the Commercial Crew and Cargo Program and its associated projects. Full funding is essential to maintaining NASA's promised $500 million investment in this program to spur the development of U.S. commercial space transportation services to and from the Space Station, while also providing substantial savings to the taxpayer compared to NASA government-owned and operated capabilities. Technical progress continues to be made by our remaining funded partner, as well by as several of our unfunded partners. NASA plans to sign a Space Act Agreement with a new funded partner in the coming weeks.

The Agency's FY 2009 budget request provides $453 million for activities in ESMD's Advanced Capabilities theme, which seeks ways to reduce the risks for human explorers of the Moon and beyond by conducting research and developing and maturing new technologies. In 2008, NASA's Human Research Program will focus on the highest risks to crew health and performance during exploration missions. We also will develop and validate technologies that serve to reduce medical risks associated with human space flight. For example, NASA will continue its work to understand the effect of space radiation on humans and to develop effective mitigation strategies. During 2008, NASA also will continue to research ways to reduce the risks to future explorers. Research on-board Space Station will include human experiments, as well as biological and microgravity experiments. In 2009, the Advanced Capabilities Exploration Technology Development program will conduct a range of activities, including testing prototype ablative heat shield materials; throttleable Lox Hydrogen engines suitable for a human lunar lander; and lightweight life support systems for Orion. The program also will deploy and test advanced environmental monitoring systems on the Space Station to advance the safety of crew members, and will continue to test in-situ resource utilization technologies as well as life support and cryogenic fluid management.

In response to Congressional direction contained in the Explanatory Statement accompanying the *Consolidated Appropriations Act, 2008* (P.L. 110–161), ESMD will fund in 2008 a robotic lander project managed by NASA's Marshall Space Flight Center in Alabama as a path-finder for an anticipated network of small science landers based on requirements for NASA's expanded lunar science program. The first lander mission is planned to fly in 2013–2014. NASA's Exploration Systems and Science mission directorates will continue to work together combining resources to ensure that the goals of the science lander are achieved.

NASA's LRO and the LCROSS have a planned launch later this year from Kennedy Space Center. These dual-manifested spacecraft are in the assembly, integration, and test phase and are making excellent progress toward launch. The knowledge generated by these missions will enable future outpost site selection and new information about resources within the permanently shadowed craters at the lunar poles. The LRO/LCROSS missions represent NASA's first steps in returning to the Moon.

Lastly, facility, infrastructure, property, and personnel transitions from Space Shuttle to Constellation continue to be a major activity. NASA transition activities are focused on managing the evolution from current operations of the Space Shuttle to future operations of Constellation and emerging commercial services, in a safe, successful and smooth process. To date, NASA has met all of its milestones and disposition targets. This joint effort between the Space Operations Mission Directorate and ESMD includes the utilization and disposition of resources, including real and personal property, personnel, and processes, to leverage existing Shuttle and Space Station assets for NASA's future Exploration activities. Formalized Transition Boards are working to successfully achieve this outcome. An initial Human Spaceflight Transition Plan was developed in 2006. An updated NASA Transition Plan, supported by key metrics, is being refined and will be released this year.

Space Operations Mission Directorate

The Space Shuttle and Space Station programs both enjoyed a highly successful and productive year in 2007. The Space Shuttle flew three missions during the year, continuing the assembly of the Station and expanding its capabilities. The June 2007 flight of Atlantis on STS–117 added a truss segment and new solar arrays to the starboard side of the Station to provide increased power. In August, Endeavour brought up another truss segment, supplies, and became the first Orbiter to use a new power transfer system that enables the Space Shuttle to draw power from the Station's solar arrays, extending the duration of the Shuttle's visits to Space Station. On the same mission, STS–118, teacher-turned-astronaut Barbara Morgan conducted a number of education-related activities aboard the Space Station, inspiring students back on Earth and realizing the dream of the Teacher In Space Project for

which she and Christa McAuliffe trained more than two decades ago. In October 2007, Discovery flew the STS–120 mission, which added the Harmony node to the Station and featured a space-walk to disentangle a snagged solar array.

The STS–120 mission paved the way for Station astronauts to conduct a series of ambitious space-walks and operations using the Station's robotic arm to move the Pressurized Mating Adapter-2 and Harmony node in preparation for the addition of the European Columbus laboratory and the Japanese Kibo laboratory in 2008. These space-walks are particularly challenging and impressive, as they are carried out entirely by the three-person Expedition crews, without benefit of having a Shuttle Orbiter, with its additional personnel and resources, docked to the Station.

NASA looks forward to upcoming Space Shuttle missions and Space Station Expeditions in 2008, which will feature the delivery, docking, and activation of key scientific assets from two of our International Partners: the European Columbus laboratory, launched just last week aboard Shuttle Atlantis, and the pressurized module of the Japanese Kibo laboratory, to be launched in April. In addition, a major contribution from Canada, the Special Purpose Dextrous Manipulator—or Dextre—will be delivered to the Station, along with the Japanese Experiment Logistics Module, in March. Dextre, the final component of the remote manipulator system provided by Canada, will act as the "hand" on the robotic arm, allowing astronauts to conduct operations and maintenance activities from inside the Space Station, rather than via space-walks. In late summer, the crew of STS–125 will become the final Shuttle crew deployed to a non-Station orbit, as they conduct the last Hubble Space Telescope servicing mission from the Space Shuttle. This mission will outfit the telescope with the Cosmic Origins Spectrograph and the Wide-Field Camera 3, as well as replace components to extend Hubble's operational life.

The Space Shuttle FY 2009 budget request of approximately $3.0 billion would provide for four Shuttle flights to support assembly of the Space Station. This would include the flight of the Japanese Kibo laboratory's Exposed Facility, and the delivery of the final Station Truss segment.

The FY 2009 budget request includes about $2.1 billion for ISS International Space Station activities, reflecting the presence of a permanent six-person crew and three major research facilities aboard Station.

After the Space Shuttle retires at the end of FY 2010, NASA will use alternative means to transport cargo and crew to the Space Station. The Agency's first choice for such services is domestic, commercial capability, the development of which is the focus of the Commercial Orbital Transportation Services (COTS) effort. ESMD is funding the first phase of COTS under the Commercial Crew and Cargo Program, which will demonstrate this capability via funded and unfunded Space Act Agreements. SOMD will manage the second phase of the effort, covering actual cargo—and potentially crew—delivery services to the Space Station. Until such time that operational commercial means are available for resupplying the Station, NASA will look to its international partners to provide cargo resupply capability, much of which will be provided as part of the partners' contributions to the International Space Station Program. NASA has contracted with Roscosmos to provide Soyuz and limited cargo services through the end of FY 2011, as permitted under the *Iran, North Korea and Syria Non-proliferation Act of 2005* (P.L. 109–112). NASA is monitoring the progress of potential domestic commercial providers to develop cargo and crew transportation services to the Space Station, and the Orion project is on track to reach its Initial Operational Capability in March 2015. The Administration is considering options to maintain a U.S. crew presence aboard the Space Station after the retirement of the Shuttle and before the advent of Orion. Purchasing crew transportation services domestically is NASA's preferred method to meet the needs of the Space Station. Another option may be to seek relief from the provisions of the Iran, North Korea, and Syria Non-Proliferation Act of 2005 for additional Soyuz services to keep a U.S. crew presence on the Space Station until either domestic commercial crew transportation services, or Orion, become available. We will keep the Congress fully informed of our plans.

NASA remains focused on, and committed to, flying out the remaining Space Shuttle missions safely and completing the assembly of the Space Station. Beyond those aims, one of the challenges NASA faces as we approach the end of the Shuttle era is the smooth disposition of personnel and infrastructure. SOMD and ESMD have been working hand-in-hand to ensure that needed skills and facilities are retained and put to productive use during the development and operational phases of the Orion, Ares I, and Ares V projects. In FY 2009, the Agency's transition milestones will include the transfer of Pad 39B and Mobile Launch Platform #1 to Constellation, after the Hubble Servicing Mission. In addition, the Space Shuttle Program is reviewing whether the Space Shuttle Atlantis will be retired in FY 2008 or used to conduct existing missions within the planned manifest.

The Space Flight Support Program's FY 2009 budget request of $733 million would help mitigate outyear costs associated with the Delta II launch pads. The request also reflects the consolidation of the Agency's space communications projects into the Space Communications and Navigation Program. Finally, it includes funding for the development of two satellites to replenish the Tracking and Data Relay Satellite System, planned for launch in 2012 and 2013.

Education

The FY 2009 budget request for Education totals $115.6 million and furthers NASA's commitment to Science, Technology, Engineering, and Mathematics (STEM) education. NASA's primary objectives for Education are to: (1) contribute to the development of the Nation's STEM workforce through a portfolio of initiatives for students at all levels; (2) attract and retain students in STEM disciplines while encouraging them to pursue higher education that is critical to NASA's workforce needs; and (3) engage Americans in NASA's mission through strategic partnerships with STEM education providers.

NASA is committed to ensuring that its future workforce is fully prepared to handle a variety of challenging scientific and technical careers. NASA's Office of Education encourages student interest in STEM through the Agency's missions, workforce, facilities, and innovations in research and technology. The FY 2009 budget request reflects a balanced portfolio of investments which takes into account Congressional priorities, the NASA Strategic Plan, and recommendations from the National Research Council, as well as the priorities of the education community. NASA Education is the critical link between the Agency's scientists and engineers and the education community. NASA Education translates the Agency's missions into educational materials, services, and opportunities for students and learners of all ages. NASA strives to support the role of educational institutions, which provide the framework to unite students, their families, and educators for educational improvement.

In 2008, NASA's Office of Education will continue to collaborate with Agency mission directorates and field Centers to assist educators in promoting scientific and technical literacy while attracting and retaining students in STEM disciplines and careers. NASA Education will also continue its work with other Federal agencies engaged in educational activities, along with public and private partners to leverage the effectiveness and reach of its efforts.

Cross-Agency Support

The FY 2009 budget request for activities within Cross-Agency Support includes funding for developing and maintaining NASA's technical capability including the Agency's vital mission support functions. Cross Agency Support provides a focus for managing technical capability and Agency mission support functions. This budget area consists of three themes: Center Management and Operations; Agency Management and Operations; and, Institutional Investments. Cross Agency Support is not directly identified or aligned to a specific program or project requirement but is necessary to ensure the efficient and effective operation and administration of NASA.

The most significant change is in the area of Agency Management and Operations. Agency Management and Operations provides for the management and oversight of Agency missions and functions and for the performance of many Agency-wide activities. Agency Management and Operations is divided into five programs: Agency Management; Safety and Mission Success; Agency Information Technology services; Innovative Partnerships Program; and, Strategic Capabilities Assets Program.

- The FY 2009 budget request provides $414.6 million for Agency Management which sponsors and supports an executive-based, Agency-level functional and administrative management agenda. Agency Management delivers policies, controls, and oversight across a range of functional and administrative management service areas and also provides for independent technical assessments of Agency programs. It delivers strategic planning services. It assesses and evaluates NASA program and mission performance. It sponsors and directs the Institutions and Management agenda in procurement, human capital, real property and infrastructure, security and program protection, diversity, equal opportunity, and small business. Agency Management also provides for the operational costs of Headquarters as an installation, including salaries, benefits, training and travel requirements of the Headquarters workforce, as well as the resources necessary to operate the Headquarters installation.
- The FY 2009 budget request provides $163.4 million for Safety and Mission Success activities to provide the critical resources required to strengthen and

enable the fundamental and robust cross checks applied on the execution of NASA's mission. The engineering; safety and mission assurance; and health and medical independent oversight and technical authority which are essential to NASA's success and were established in direct response to recommendations of the *Challenger* and *Columbia* Shuttle accident board recommendations for independent funding of these efforts. The Safety and Mission Success program directly supports NASA's core values and serves to improve the likelihood for safety and mission success for NASA's programs, projects, and operations. Safety and Mission Success includes the corporate work managed by the offices of the Chief Safety and Mission Assurance (including the NASA Safety Center), Chief Engineer (including the NASA Engineering and Safety Center), the Chief Health and Medical Officer, and the Director of the Independent Verification and Validation Facility.

- The FY 2009 budget request for Agency Information Technology services is $163.9 million which encompasses cross-cutting services and initiatives in IT management, applications, and infrastructure necessary to enable the NASA Mission and improve security, integration and efficiency of Agency operations. In FY 2009 significant emphasis will be placed on consolidation of networks and network management, improved security incident detection, response and management, further consolidation of desktop/laptop computer services, data center assessment for consolidation, and application portfolio management leading to consolidation. NASA is using an enterprise architecture approach to assess current assets, capabilities and costs for services and developing requirements, projects and procurements for transition to the desired consolidated state. Additionally, the underlying infrastructure and systems to instill strong authentication and access to information systems in alignment with HSPD–12 will progress significantly in FY 2009. Critical work will continue under the Integrated Enterprise Management Program to improve business processes by minimizing data redundancy, standardizing information and electronic data exchanges, and processing. Also, NASA will continue participation in several federal E–Government initiatives and Lines of Business to improve services to citizens and gain efficiencies across the government.
- The FY 2009 budget request for Innovative Partnerships Program activities is $175.7 million. This program provides leveraged technology investments, dual-use technology-related partnerships, and technology solutions for NASA. This program also facilitates the protection of NASA's rights in its inventions and the transfer of that technology for commercial application and public benefit. In addition, the Innovative Partnerships Program implements NASA's Small Business Innovation Research and Small Business Technology Transfer Programs which seek out high-technology small businesses to address key technology needs for NASA. The program also manages a Seed Fund to address technology needs through cost-shared, joint-development partnerships. The Centennial Challenges Program, which is also managed by the Innovative Partnerships Program, consists of prize contests to stimulate innovation and competition in new technologies for solar system exploration and other NASA mission areas. NASA has already benefited from Centennial Challenge competitions, and last year awarded $450,000 in prize money for the Astronaut Glove Challenge and Personal Air Vehicle Challenge. The Innovative Partnerships Program also transfers NASA technology for public benefit, as documented in NASA's annual "Spinoff" publication. "Spinoff 2007" documented 39 new examples of how NASA innovation has been successfully transferred to the commercial market place and applied to areas such as health and medicine, transportation, public safety, consumer goods, homes and recreation, environmental and agricultural resources, computer technology, and industrial productivity.
- Finally, NASA is requesting $28.0 million in FY 2009 for the Strategic Capabilities Assets Program, a focused activity designed to ensure that critical Agency capabilities and assets for flight simulation, thermal vacuum testing, arc jet testing, and microgravity flight services are available to NASA missions when needed. Strategic Capabilities Assets Program assets are also used by other government agencies, industry, and academia to improve the Nation's position in the global market place as well as its defense capabilities. The Strategic Capabilities Assets Program budget request covers the direct and associated costs required to sustain key test capabilities and assets including operating staff, preventive maintenance, subsystem repairs, and component replacements required to keep the assets in "ready for testing" condition. Incremental costs to conduct specific tests are borne by individual pro-

grams and reimbursable customers. The Aeronautics Research Mission Directorate budget request includes $73.9 million for the Aeronautics Test Program (e.g., wind tunnels and flight testing) and the Science Mission Directorate budget request includes $41.9 million for High-End Computing Capability (e.g., the Columbia super computer), which are also managed as Strategic Capabilities Assets. Centralized management at the Agency-level allows NASA to better prioritize and make strategic investment decisions to replace, modify, or disposition these capabilities and assets.

Conclusion

NASA has a lot of hard work ahead, but the Agency continues to make steady progress in managing its challenges. We are deploying our workforce to carry out the great task before us. Last fall, the Agency assigned new leadership roles and responsibilities for exploration and science missions to NASA's ten field Centers across the country in order to help restore the core technical capabilities across the Agency as we transition from the Space Shuttle to new capabilities. I ask your continued help to ensure that this nation maintains a human space flight capability.

In a short span of years, we have already taken long strides in the formulation of strategies and programs that will take us back to the Moon and on to Mars and other destinations in our solar system. Indeed, a generation from now, astronauts on Mars will be flying and living aboard hardware America is funding and designing today, and will be building in the near future. This is a heady legacy to which we can aspire as we develop the next U.S. human space exploration vehicles. The foundation of this legacy will include work we plan to carry out in FY 2009.

As I said earlier in my testimony, NASA is committed to executing the exciting programs and projects within the President's FY 2009 budget request. Having reached a steady state on a balanced set of priorities, we now have a sense of purpose to make steady progress toward achieving our goals for continued leadership in space exploration, scientific discovery, and aeronautics research.

Chairman Gordon, with your support and that of this committee, we are making the right strategic choices for our nation's space program. Again, thank you for the opportunity to appear before you today. I would be pleased to respond to any questions that you may have.

National Aeronautics and Space Administration
President's FY 2009 Budget Request Summary

Budget Authority, $ in millions By Appropriation Account By Theme	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Science	**4,609.9**	**4,706.2**	**4,441.5**	**4,482.0**	**4,534.9**	**4,643.4**	**4,761.6**
Earth Science	1,198.5	1,280.3	1,367.5	1,350.7	1,250.9	1,264.4	1,290.3
Planetary Science	1,215.6	1,247.5	1,334.2	1,410.1	1,537.5	1,570.0	1,608.7
Astrophysics	1,365.0	1,337.5	1,162.5	1,122.4	1,057.1	1,067.7	1,116.0
Heliophysics	830.8	840.9	577.3*	598.9	689.4	741.2	746.6
Aeronautics	**593.8**	**511.7**	**446.5**	**447.5**	**452.4**	**456.7**	**467.7**
Exploration	**2,869.8**	**3,143.1**	**3,500.5**	**3,737.7**	**7,048.2**	**7,116.8**	**7,666.8**
Constellation Systems	2,114.7	2,471.9	3,048.2	3,252.8	6,479.5	6,521.4	7,080.5
Advanced Capabilities	755.1	671.1	452.3	484.9	568.7	595.5	586.3
Space Operations	**5,113.5**	**5,526.2**	**5,774.7**	**5,872.8**	**2,900.1**	**3,089.9**	**2,788.5**
Space Shuttle	3,315.3	3,266.7	2,981.7	2,983.7	95.7	-	-
International Space Station	1,469.0	1,813.2	2,060.2	2,277.0	2,176.4	2,448.2	2,143.1
Space and Flight Support	329.2	446.3	732.8*	612.1	628.0	641.7	645.4
Education	**115.9**	**146.8**	**115.6**	**126.1**	**123.8**	**123.8**	**123.8**
Cross-Agency Support	**2,949.9**	**3,242.9**	**3,299.9**	**3,323.9**	**3,363.7**	**3,436.1**	**3,511.3**
Center Management and Operations	1,754.9	2,013.0	2,045.6	2,046.7	2,088.0	2,155.3	2,211.6
Agency Management and Operations	971.2	830.2	945.6	945.5	939.8	950.5	961.3
Institutional Investments	223.8	319.7	308.7	331.7	335.9	330.4	338.3
Congressionally Directed Items	-	80.0	-	-	-	-	-
Inspector General	**32.2**	**32.6**	**35.5**	**36.4**	**37.3**	**38.3**	**39.2**
FY 2008 Rescission**		(192.5)					
NASA FY 2009	**16,285.0**	**17,309.4**	**17,614.2**	**18,026.3**	**18,460.4**	**18,905.0**	**19,358.8**
Year to Year Change		6.3%	1.8%	2.3%	2.4%	2.4%	2.4%

Budgets include all direct costs required to execute the programs. Indirect costs are now budgeted within Cross-Agency Support.

* Deep Space and Near Earth Networks Transfer $256M to SFS in FY 2009.

** FY 2008 Appropriation rescinded $192.475M in prior-year unobligated balances, effectively reducing FY 2008 authority. Not included in totals.

FY 2008 budgets are the enacted levels per the FY 2008 Appropriation as shown in the Agency's FY 2009 Budget Estimates.

Totals may not add due to rounding.

DISCUSSION

Chairman GORDON. Thank you, Dr. Griffin, for your testimony and more importantly for your service to our nation.

In respect of your time we are going to try to do a tag team. Mr. Udall and Mr. Feeney have already gone. We are going to temporarily adjourn, which I hope is no more than two or three minutes, as they come back, and then we are going to go vote, and we will be back.

Dr. GRIFFIN. As always I am at your——

Chairman GORDON. So let us just, everybody stay tuned, and we will hopefully in just in a matter of two or three minutes be started again.

Dr. GRIFFIN. Yes, sir.

[Recess.]

AERONAUTICS FUNDING

Mr. UDALL. [Presiding] The Committee will come back to order. I would note for everybody who is here that Ranking Member Feeney and others have informed me that we will see a series of procedural votes throughout the rest of this hearing, so we are going to proceed with questions for Dr. Griffin, and hopefully everybody here, the Members here will have a chance to direct their questions.

Dr. Griffin, I will yield myself five minutes.

Dr. Griffin, as you know, I have long been concerned about the state of NASA's aeronautics programs, especially those focused on aviation safety and on improving the efficiency of the Nation's air traffic management system. The erosion of the aeronautics budgets over the last seven years or more calls into question the ability of NASA to continue to make significant contributions to either of those important areas.

That is not just my view. It is a warning voiced repeatedly by multiple hearing witnesses over the last several years. As I look at the '09 budget request, I am struck by the fact that all three of the main NASA aeronautics research accounts, that is Aviation Safety, Airspace Systems, and Fundamental Aeronautics are each essentially flat over the next five years. That to me is a keep-alive strategy driven by inadequate budgets rather than a strategy that is geared toward identifying the key challenges facing aviation and building R&D programs and budgets to address those challenges.

So let me do this. Let me ask you if you were to receive additional funding from Congress, aeronautics funding, because obviously you aren't going to get it from this ONB, what would you consider to be the highest priority for those additional funds; aviation safety, next gen air transportation systems support, or something else?

Dr. GRIFFIN. Thank you. Sir, I would want to provide a detailed answer on that for the record because our program does not contemplate the addition of funds to it. But loosely speaking I would offer that I know that we are meeting in conjunction with the FAA and our other partners all of our obligations on NextGen. There is always more research to be done, but the FAA will tell you that NASA is meeting its obligations to the JPDO on NextGen.

Aviation safety is, again, a well-funded program. We are doing numerous activities in cooperation with the FAA on aviation safety. I am pretty happy with that.

So I would probably put additional money into fundamental aeronautics research to get at the underlying aeronautical science advances. I was thrilled with our work on blended wing body systems last year and the potential advantage that such a system has to increase efficiency, reduce emissions, enhance safety, provide quieter rides, all of those things for future air transport. Fundamental aeronautics and NASA could, one could always do more work with more money.

CLIMATE RESEARCH

Mr. UDALL. Well, thank you for peering over the horizon for the Committee, and I do agree that investment in more fundamental research would really pay dividends.

Let me turn to climate research. I am encouraged by your plans to start work on the, to the high-priority Earth science missions recommended by the National Academies, and I am also glad to hear that at last there appears to be some progress on finding homes for the climate instruments that have been removed from NPOESS spacecraft as you are well aware.

However, I am unclear about NASA's plans for at least one of those instruments, the total solar irradiance sensor. I think it is also known by its acronym, TSIS, and specifically can you tell me when a decision will be made as to how and when the TSIS instrument will be flown, what is driving the decision on where to manifest the instrument, what is your responsibility, NASA's that is, regarding the instrument, especially in 2008 and 2009 fiscal years? What is the status of the instrument development team, is the team fully funded, and if so, have those funds actually been dispersed yet to the team? And when does the instrument, the TSIS instrument, need to fly in order to avoid data gaps in the total solar irradiance measurements?

A lot of question. Thank you for dealing with all of them.

Dr. GRIFFIN. That is a lot of questions. Yes, sir. And to answer all those in an appropriate fashion I will again provide a detailed answer on the record. Let me give you, again, a top-level summary.

Our immediate priorities are to fly VIRS and CERES instruments, the highest priorities that we have. TSIS is important. The measurements that it makes is critically important, but we have ongoing other ways to make that measurement so that the flying of TSIS by itself is not our immediate highest priority.

The instrument development team is funded at a lower level, of course, than they would like, but it is funded, and we are looking for the right flight for TSIS. We haven't found it yet. We will identify that to you as soon as we can, but, again, I want to close the summary answer here by saying that the continuity of the measurement is, that TSIS makes is what is most important. We have other sensors which are going to insure the continuity of this particular measurement, and so the exact date on which we fly TSIS is not our first priority at the moment.

Mr. UDALL. Thank you, Dr. Griffin. The Chair is honored and excited to recognize the Ranking Member of the Full Committee, Mr. Hall, Judge Hall, from the great State of Texas.

Mr. HALL. Any Udall is all right with me. Chairman, thank you.

THE FUTURE OF HUMAN SPACE FLIGHT

Mike, NASA has given us a good plan to replace the Space Shuttle with the Ares 1 for crew access to space and later add the Ares 5 for heavy cargo to space, and it is a plan that I support and which the Congress has agreed to. Nonetheless, there are a lot who continue to second guess this architecture and suggest that we might be able to use one of the existing Atlas 5 or Delta 4 launchers to take our crews into space.

I know NASA has looked at this closely, and I am sure you have made the right decisions, but would you summarize again for us the factors that led NASA to conclude that a new launch vehicle was needed for the Orion spacecraft? And go slow where even I can understand it.

Dr. GRIFFIN. Yes, sir. I have dealt with this question a lot. At the top level, let me point out what is at issue here. At the top level, I think we need to recognize that it is not a question——

Mr. HALL. You know, you cause that bell to ring for some reason. I don't know how that happens.

Dr. GRIFFIN. I must.

Mr. HALL. But go ahead.

Dr. GRIFFIN. It is not a question of whether we are going to use a new system for Constellation or an existing system. If that were the trade, I would be on the side of using the existing system. What has not been recognized is that there is no system today which can meet the Constellation requirements.

So the question is are we going to upgrade the EELV family to meet Constellation needs, or are we going to upgrade the Shuttle-derived family to meet Constellation needs? No system in existence today can meet our needs. So the question is would we use a Shuttle-derived architecture or an EELV-derived architecture. When we examined the situation closely, it turned out that the lowest-risk solution, the highest-performance solution, and the lowest-cost solution was obtainable by using our Shuttle hardware heritage as opposed to our EELV hardware heritage. There is nothing wrong with either system, but when the issues of performance, cost, and risks are considered, the Shuttle-derived won.

I think that is the kind of decision that you would want me to make.

Mr. HALL. Let me go a step further and ask a quick question. I think yesterday in California there was a group of leading space, I guess so-called space policy experts. They may be experts, discussing the direction and content of vision for space exploration. They are particularly critical about using the Moon as an interim step for eventually traveling to Mars. Would you care to share any thoughts about the need for a lunar program since we have been there——

Dr. GRIFFIN. Well——

Mr. HALL.—more than once?

Dr. GRIFFIN.—yes, sir. I am always intrigued by the idea that since we have spent a few days on the Moon that the place is now uninteresting for all future time and that we should ignore it and head straight for Mars. So first of all, I believe that people will find the Moon to be an exciting and interesting place for human beings in the future, and I strongly support its inclusion as an appropriate destination for humans, as I do Mars.

The argument that this group of space policy experts is putting forth comes down fundamentally to one about the choice of destinations. They do not see the Moon as a valuable destination. I do. They would prefer that the funds that we are presently allocating toward returning to the Moon and then going to Mars be utilized to put large telescopes near one of the Lagrange points to visit near-Earth asteroids and to go more quickly to Mars.

I regard that as foolish frankly. The Moon is three days and a quarter million miles from home. When we return to the Moon, we will not have been there for 50 years. The Lagrange points, even granting as I absolutely do, their immense value as sites to host large telescopes, are a million miles away and weeks away from home going and coming. The near-Earth asteroids, which I also am interested in and believe should be an appropriate destination, are many months away from home, and Mars is further yet.

So a correctly-orchestrated space program would take us outward from Earth orbit to the nearest possible destination, which is the Moon, and then would take us outward from there to successively farther destinations as we consolidate our capabilities and consolidate our gains. That is the program we have in place. That is the program that this Congress passed in the 2005 Authorization Act. It is the properly-arranged program.

So I just—I cannot agree with so-called space policy experts who believe that the Moon is not an appropriate goal for our exploration efforts.

Mr. HALL. I saw Buzz Aldrin just a little bit ago, and he sure doesn't look like a guy that 40 years ago that he was up there. He must have been five when we sent him up.

Dr. GRIFFIN. Buzz is my hero. I wish to be in his condition at that age.

Mr. HALL. Mine, too. I wished he would have stepped off first, and I think he was scheduled to. He says he was.

Dr. GRIFFIN. But anyway, let us move past that one.

RUSSIAN TRANSPORTATION

Chairman GORDON. Thank you, Mr. Hall. We will let the bells continue. Once again, Dr. Griffin, we are going to do a tag team here.

In your testimony you spent a lot of time discussing the need for Russian transportation after the 2011, during this gap period.

Dr. GRIFFIN. I did, sir.

Chairman GORDON. And you also talked about how you are going to be, move forward with the negotiated contract and that you can't do that without some change in the *Korean and Syrian Non-Proliferation Act.* So do you expect the Administration to send us a formal request for that legislative action?

Dr. GRIFFIN. Yes, sir. My comments today were in the nature of a heads up.

Chairman GORDON. The Administration will be sending something?

Dr. GRIFFIN. I hope so. I have initiated those conversations within the Administration. It is my intent to seek such a request, coordinate. Obviously it requires a coordination among many agencies, but I intend to do everything I can to press it forward simply because of the timelines involved. As I point out, our authorization to utilize Russian services expires in 2011.

Chairman GORDON. Right. You made that point.

Dr. GRIFFIN. So if we want to fly in——

Chairman GORDON. I understand that but——

Dr. GRIFFIN. Okay. Yes, sir.

Chairman GORDON.—to be successful you are going to have to have this initiated from the Administration.

Dr. GRIFFIN. That is correct, sir. And I intend to press for that.

Chairman GORDON. Okay.

Dr. GRIFFIN. I do not have that authorization yet. I intend to——

Chairman GORDON. And when would you expect that you would have that?

Dr. GRIFFIN. I need it by this summer.

Chairman GORDON. No, no, no. I mean, when would you expect, when there is a timeframe, when would you expect the Administration to decide this was worthy and then to make the request?

Dr. GRIFFIN. I don't know.

Chairman GORDON. When do you think it would be too late if they didn't?

Dr. GRIFFIN. It needs to be done within this Administration, so prior to next January.

Chairman GORDON. And through the legislative process also.

Dr. GRIFFIN. Yes, sir.

IMPACT OF FUNDING SHORTFALLS ON ISS PROGRAM

Chairman GORDON. Okay. Dr. Griffin, as you know, NASA has been forced to operate in a very constrained budgetary environment in recent years as we have discussed today. I want to make sure that this committee is aware of any areas in this budget request that there are funding shortfalls that a future Administration and Congress will need to deal with.

In that regard, how confident are you that sufficient funding has been set aside in NASA's five-year runout budget to pay for the ISS crew and cargo transportation?

Dr. GRIFFIN. Wow. That calls for a conclusion of the witness, which as a former prosecutor I think you are familiar with. Let me offer you the range of possibilities if I might.

In March of '07, we did, in the course of preparing the Space Station Utilization Plan that this committee asked for and which we have furnished you, we did a very careful assessment of crew and cargo requirements, and to utilize the station after it is assembled, we came up with a range from 32.5 metric tons to just under, call it 45 metric tons of cargo, depending on the degree that the U.S. laboratory is utilized. If it is fully utilized, it is the 45 metric tons, and if it is less, though, it would be 32 metric tons.

The, I don't want to quote specific numbers, because it affects procurement actions, but I can phrase it this way: If we utilize the station only at the low end of our estimates, then future commercial procurements of cargo would have to do no worse than we are doing today at a time when, of course, we will be in much more of a hostage situation than we are today. Today we have alternatives and after the Shuttle is retired, we won't.

So looking forward at the minimum possible utilization of the station with 32 metric tons of cargo, looking past 2010, we would have to do at least as well as we are doing today for a contractual price. If we are fortunate enough, as I hope we would be and I know you are, too, to get a heavy utilization of the station, then at the 45 metric ton level, then we would have to do somewhat better in the outyears than we are doing today with our commercial procurement of cargo. And I don't consider that to be very likely.

Chairman GORDON. So——

Dr. GRIFFIN. I hope I was clear without quoting numbers that I don't want to quote in public.

Chairman GORDON.—to avoid either significant additional funds or cannibalizing other programs, everything has to go just right, no inflation, and the Russians have to not take advantage of their hostage position.

Dr. GRIFFIN. Or other potential suppliers in that same timeframe. Yes, sir. That would be correct.

CHINESE LUNAR PLANS

Chairman GORDON. I think it might be beneficial, Dr. Griffin, we had a conversation yesterday at which time I said to you that approximately three years ago when we were discussing the ability of China to get to the Moon and a timeframe, that you somewhat poo-poo'd their ability, that they did not have the infrastructure, and you really weren't particularly concerned about that.

Have you changed your, I won't say changed. Has your opinion been more informed, or have you gained additional information, and what is your thought about that situation now?

Dr. GRIFFIN. I have gotten a lot of questions on that lately, sir, and I would be happy to answer this one. And I don't mind if you say that I changed my mind. I often do that in response to new data.

Chairman GORDON. Yes. Sure. Which is—there is nothing wrong with that.

Dr. GRIFFIN. You are correct. A few years ago I was not particularly concerned about Chinese primacy in human space flight relative to that of the United States. Since then their accomplishments, as well as their stated plans, combined with my visit to China, combined frankly with an assessment of what is available from open sources on the Internet, lead me to believe——

Chairman GORDON. Dr. Griffin, if you don't mind, again, we are trying to accommodate your time. We are going to go, I think this is important for the broader view for us to know. We are going to have to go vote, and Mr. Hall had a question first.

Mr. HALL. Would you say that you are less poo-poo'd toward China now than you were?

Dr. GRIFFIN. Yes, sir, I would, and I am, I can extend my time here to as long as you need.

Chairman GORDON. No. I think as long as there are questions, but I hate for there to be gaps.

Mr. Lampson will take over, and I wish, if you would, please, so, for the broader audience to complete that answer.

Dr. GRIFFIN. Complete that answer. I will do so, sir.

So, and as I was saying, as well as an assessment of what is available from open sources, in particular the capability of the Long March 5 and the Chinese dual launch processing capability that they have already demonstrated, I have become convinced that it is possible for China to mount a human lunar mission toward the end of the next decade and quite possibly before we are able to return. I can provide that, the analysis that leads me to that conclusion for the written record if you would like. There is nothing in it which is classified or in any possible way, so if you would like that analysis for the written record, I can provide it.

Mr. LAMPSON. [Presiding] I think it would be appropriate——

Dr. GRIFFIN. Okay.

Mr. LAMPSON.—for us to have that.

Dr. GRIFFIN. I would be happy to do that. And in summary, I think that a human lunar mission is clearly within Chinese capabilities by a decade from now should they choose to do it, and their own outline of plans convinces me that they may well be. [*See Appendix 2: Additional Material for the Record.*]

Mr. LAMPSON. I think it is something that we need to take a special note of, and my opinion, what I believe personally that we may be in a bigger period of challenge today than what we were in 1957. We just don't hear the beeps. Somehow or other we have got to start hearing them before they become a roar.

I think his time has expired, and I got those words in under his time, and I will recognize myself for five minutes and continue questioning Dr. Griffin.

Again, I, too, want to add my welcome.

Dr. GRIFFIN. Thank you.

THE ALPHA MAGNETICS SPECTROMETER

Mr. LAMPSON. I want to turn our attention to the alpha magnetics spectrometer about which we have had many conversations, and I know that you know that I believe that it is not only an important scientific research initiative but one that represents a significant international scientific collaboration. And so I have got a whole long series of questions, and if you will keep them as short as possible, I will try to get through them as easily as we possibly can.

But how important do you believe it is for the United States to be seen as a reliable partner in international scientific undertakings such as this?

Dr. GRIFFIN. I know where this is going. I will try to be short with my answers. I am well on record as believing that when the United States makes commitments, they should be kept.

Mr. LAMPSON. And obviously believing that, would you also agree that NASA should strive to meet its commitment to the International AMS Partnership if a practical way can be found to do so?

Dr. GRIFFIN. I, again, of course, we should strive to meet our commitments if it is possible to do so.

Mr. LAMPSON. Congress hasn't yet received the, NASA's report on the AMS Project that was requested in the appropriation, and speaking as an engineer with many years experience in various space projects, what do you think would be the lowest cost, lowest risk way to deliver the AMS experiment to space in a timely manner?

Dr. GRIFFIN. The report that you seek is awaiting clearance within the Administration. It will be provided to you as soon as we can do it. But to answer your question directly, the AMS was designed to go on-board a Space Shuttle, and that is the clearly lowest cost, most straightforward, lowest risk approach to putting it on orbit. I mean, other means are possible, but that is the most straightforward way. [*See Appendix 2: Additional Material for the Record for the report on the AMS.*]

Mr. LAMPSON. Okay. Do you have the authority to add an additional Shuttle flight to the manifest on your own, or would you need to be directed to do so?

Dr. GRIFFIN. I do not have that authority. If I had that authority, I would have added the Shuttle flight, and we would not be having this discussion.

Mr. LAMPSON. Consequently, if you lack that authority to add the Shuttle space flight on there, who would need to direct you to do so? OMB or Congress?

Dr. GRIFFIN. Well, OMB does not provide direction to NASA. OMB provides advice to the President, who directs NASA.

Mr. LAMPSON. So it would be——

Dr. GRIFFIN. Of course, superceding even that is the law of the land. Now, the budget that Congress has appropriated for me and the authorization that Congress has provided to me does not include at this point an additional Shuttle flight. Every Shuttle flight that we plan to fly has been identified for the Congress and has been the subject of appropriated funds.

So I have neither permission from the President nor authorization nor appropriation from Congress to fly another Shuttle flight.

Mr. LAMPSON. So neither the President nor OMB has indicated to you that it intends to direct you to add an additional Shuttle flight to fly the AMS experiment?

Dr. GRIFFIN. Well, again, the OMB does not direct NASA however much they might wish to. The—but the Administration has not requested funds for an additional Shuttle flight, and the Congress has not authorized or appropriated such funds. So I, as the Administrator, do not make space policy. I carry it out, and no, none of my governing entities has asked me to do this flight.

Mr. LAMPSON. By when would Congress have to direct you to take all necessary steps to fly an additional Shuttle flight to deliver the AMS experiment to space for it to be possible by the time the Shuttle is scheduled to be retired? End of the year, end of the fiscal year, end of the calendar year, later than that?

Dr. GRIFFIN. The end of this calendar year, January, '09 at the latest, or it is a done deal, because our manifest is coming to a close. We are flying the flights that we are authorized to fly with the hardware that we have bought and with the contracts that we

have in place. If the Congress chooses to add another flight to our manifest, they need to tell me this year, within this calendar year.

CONTINGENCY FLIGHTS AND THE ISS

Mr. LAMPSON. Okay. I am concerned that the current approach to the ISS assembly may wind up jeopardizing its future viability. Specifically the NASA manifest currently book keeps as contingency flights, the two Shuttle flights that are intended to fly critical spares and logistics to the ISS prior to the Shuttle's retirement.

It is my understanding that OMB doesn't consider those two flights to be part of the baseline Shuttle manifest. Is that correct?

Dr. GRIFFIN. Sir, I can't get into what different offices in the Executive Office of the President think or don't think. I have, since my time as Administrator, I have used several words inappropriately to my nearly everlasting regret. One of those was labeling those flights contingency flights. I was speaking too much as an engineer and not recognizing the policy import of that. In fact, those flights carry up, they are designed to carry hardware to support the station in the event of failure of certain systems. And given what we have experienced in terms of the failure rate of existing on-board systems, the spare units and other logistics material that those flights are manifested are not contingency flights. They are not contingency flights. They are necessary flights if we are to sustain the station through the five-year gap between retirement of the Shuttle and the deployment of Ares and Orion. Because that, every bit of statistical information we have says that that equipment will be needed.

And I deeply regret any confusion I have caused this committee by labeling them some years ago as contingency flights. They are spare hardware, and they are necessary in one fashion or the other. The question becomes what is the easiest method to get them up, and that is with the Shuttle.

Mr. LAMPSON. And they are required if we want to ensure that the ISS remains a viable and useful facility after the Shuttle is retired?

Dr. GRIFFIN. If you want to ensure that the ISS remains vital and useful as opposed to gambling on it, then, yes, sir, they are required.

Mr. LAMPSON. If you are not permitted to fly those flights or if we don't provide the resources, whatever is necessary, what other critical options, if any, does NASA have to deliver those needed spares and logistics?

Dr. GRIFFIN. Well, those flights, the funding for those flights is at present in our budget. So we can fly those with what we have. Now, credible, there are no immediately credible alternatives because the systems that I am talking about would have to be remanifested on expendable vehicles with, and fitted with automated rendezvous and docking systems and such that don't currently exist that we are hoping will be developed for other commercial crew and cargo.

So like other aspects of space station logistics support, they would have to be manifested on systems that don't yet exist.

Mr. LAMPSON. Thank you very much. Dr. Griffin, my time is expired, and I yield to Mr. Feeney of Florida.

THE FY 2009 NASA BUDGET AND ARES AND ORION TEST FLIGHTS

Mr. FEENEY. Thank you, Mr. Chairman. As we run back and forth here in the rain and everything else, I think I know what you are thinking. You are probably admiring the efficiency and the work habits of the United States Congress, Mr. Administrator, but again, we appreciate you being here.

Dr. GRIFFIN. Maybe you could take another break or two after that last round of questions.

Mr. FEENEY. Well, I hope mine will be, I hope mine won't be so taxing.

You know, I would like to point out that the budget that you requested this year is $17.6 billion. My numbers show that if adjusted for inflation since 1992, the budget would have been in today's dollars $20.3 billion, which means roughly a $3 billion real cut relative to the NASA budget in 1992, almost a 20 percent reduction during the 1990s and the early part of the new millennium. And I think all of us have, you know, felt the challenge and the pain of dealing with that.

I want to ask you as we talk about completing the International Space Station, several weeks ago there was some public discussion about the schedule possibly slipping for the Ares 1–Y and the early Orion test flights. Could you set the record straight for us and right now according to your latest reviews are you anticipating that there might be such slippage? And if there is going to be a decision about whether there is likely to be slippage, when do you anticipate that decision?

Dr. GRIFFIN. First of all, I will comment on your remark about the decrement in the budget over the '90s. Yes. It is absolutely true. In real dollars we lost some ground, several billion dollars during the 1990s which has not been recouped since then. So you are right.

Regarding the Ares 1–Y flight, there was some discussion a few weeks ago in, within NASA and including a memo that was released prematurely, saying that we were going to move the Ares 1–Y flight date. Now, the goal behind that thinking was to offer the highest confidence of preserving the IOC, the initial operational capability date, the IOC date for the finished system. So it was just a matter of shuffling the deck chairs around to get the most comfortable seating for everybody.

We, after looking at it more carefully, in fact, decided not to move that, the Ares 1–Y test flight date at this time. We don't have a need to move it at this time, and so we are not going to do it. So I would say that is in abeyance indefinitely. If we do decide to shuffle our flight test schedule, you have my absolute commitment to share that information with your staff, make sure that everybody is on-board as to what our flight test schedule is.

I do want to reserve the right to plan the flight test schedule in the most sensible engineering manner possible, and we, I am not saying that we would never move our dates around, but right now we are not doing that.

Mr. FEENEY. In terms of completing the Shuttle mission, if it becomes necessary because of slippage or time tables or desirable to fly the last two contingency, you said we are no longer referring to these as contingency missions.

Dr. GRIFFIN. Well, I will never be able to get rid of it, but I wish I had not used that term.

Mr. FEENEY. The so-called—the re-supply missions. If it becomes necessary to do that after 2010, do you have an estimate of what the cost would be to continue the Shuttle operations on a monthly or annual basis?

Dr. GRIFFIN. Well, we, having bought all the hardware already and having included in the budget that which is necessary to fly the manifest out to those last couple of flights, if, you know, if we didn't get an appropriation, for example, in 2010, until December as opposed to September, and or if the schedule slipped or anything, there would be no problem flying the last couple of Shuttle flights out through the end of calendar year 2010.

So the program is not sensitive to whether the last flight occurs in September of 2010, or December of 2010. We don't care.

Now, to go beyond that, okay, we have to keep contractors in place and contracts alive that we intend to cancel. And so that then brings into play the carrying cost of the whole Shuttle infrastructure, which is around $3 billion a year just to own the fleet and keep it active.

Now, I can provide, I said around $3 billion. If you would like for the record, I can give you a more-detailed answer, but the number, the carrying cost for the Shuttle fleet is around $3 billion a year, and I need to end that in 2010, so that I can move on with new systems.

Mr. FEENEY. Very good. I will yield back the balance of my time.

Chairman GORDON. Thank you, Mr. Feeney. Thank you for the good job you are doing as our Ranking Member on this subcommittee.

SPENDING, MARS AND NEAR-EARTH OBJECTS

Mr. Udall is recognized, former Chairman—Rohrabacher. Excuse me. Rohrabacher is recognized. Former Chairman and Ranking Member of the Space Subcommittee.

Mr. ROHRABACHER. Thank you very much, and I will commend my Chairman, Subcommittee Chairman, Mr. Udall. He is doing a good job. I would be very happy to be mistaken for Congressman Udall and also let me note that, Mr. Chairman, you are doing a great job, and both the Subcommittee Chairmen and the Committee Chairman in dealing with space issues. I would applaud those leaders who are showing bipartisan and I would say very responsible approach in working with those of us who on the other side of the aisle to try to make sure that we fund the space program and make it successful. Thank you, Mr. Chairman.

Also some accolades for Administrator Griffin.

Dr. GRIFFIN. Yes, sir.

Mr. ROHRABACHER. I consider you to be, I have been here 20 years now. When I got on this committee, I was sitting way over on the other side there, and I was at first. Twenty years ago I came in here, and of all the NASA Administrators that I have seen come

through here you are the most innovative and creative and responsible [inaudible]. I say that without hesitation. So I congratulate you for keeping a positive spirit in the midst of a—must be a—just a bureaucratic challenge that would just overwhelm so many other people.

We talked today about the $17.6 billion that is being requested. You have taken an approach that development of new technology and encouraging private sector investment, as well as restructuring NASA to be more efficient, are ways that can put those dollars to better use. So although it is easy for us just to focus on the dollar amount, that doesn't tell the whole story, and in fact, if we gave, we just keep up with inflation but would have less innovation, it would not be serving the interest of the American people.

So I would congratulate you on not just taking the approach that we just need to back up the federal truck and shovel more dollars out in to the NASA building. Instead that we prioritize efficiently.

With that said, I liked your answer in terms of EELV versus Shuttle technology upgrade. I would like to learn more about that [inaudible].

Chairman GORDON. Mr. Rohrabacher, I think that particular microphone——

Mr. ROHRABACHER. Maybe I am not up close enough.

Chairman GORDON. Okay.

Mr. ROHRABACHER. I was leaning back.

Chairman GORDON. Okay. Okay.

Mr. ROHRABACHER. That Red Bull that I had earlier today——

Chairman GORDON. We are all intensely interested in your——

Mr. ROHRABACHER. Yes. The, what, in terms of actually spending the money, you mentioned, of course, the 2005 Space Authorization, which laid a roadmap, and again, I take great pride in that, because I participated in that. And it was, of course, President Bush, who after a long, long time gave us at least a roadmap to look at, which other Presidents had not done.

But you talk about Moon and Mars as destinations, and you talk about the step approach. Are we spending, of the $17.6 billion, is there money being spent now on developing technologies that are not necessary for the first steps but are only being spent for a preparation for a Mars expedition?

Dr. GRIFFIN. No, sir. The appropriations law for '08, the situation, of course, is a bit complicated. This committee, the Congress has authorized us to develop a sustained lunar presence and to prepare the way for Mars, and I am not quoting exactly, but that is the thrust of it.

However, the fiscal year 2008 Appropriations Act enjoins us from spending any money on any technology that would be just for Mars. And so we are not doing that this year.

Mr. ROHRABACHER. Well, that is the right answer.

Dr. GRIFFIN. I would hope that that could be removed in future years.

Mr. ROHRABACHER. Well, it depends on how close we are getting. You know, quite frankly, I believe by the time we go to Mars, that there will be such different technology capabilities, hopefully better technology capabilities, available to us that it might be wasteful to spend money right now on putting together technology that might

not be used for 20 years and then 20 years from now there would be other technology that would be better.

Dr. GRIFFIN. Well, yes, sir. I agree, but literally interpreted the restriction puts questions on our utilization of the Space Station to study the adaptability of human beings to long-term space flight. So——

Mr. ROHRABACHER. I see.

Dr. GRIFFIN.—we are not interpreting it that way because I think the Congress wants us to do research on the Space Station, but the reason for doing research on the Space Station is for voyages farther away than three days, which is where the Moon is.

Mr. ROHRABACHER. Well, there was questions about the Space Station, whether or not that decision that was made so long ago was a right decision or wrong decision, and what you just brought up was a complication of that.

Dr. GRIFFIN. You are right. I have chosen to move past the Space Station decision——

Mr. ROHRABACHER. Right.

Dr. GRIFFIN.—to accept it as done, finish the station, and then let us get on outward beyond Earth orbit.

Mr. ROHRABACHER. And if you would, if the Chairman would indulge me for just a few more moments, the Arecibo telescope and the near-Earth object mission that obviously is of great concern to me and I think to the American people as well, you made it very clear that you are willing to help, and NASA should be part of this, but that you don't have the budget for it.

If we, indeed, come back with an authorization for NASA that is above the $17.6 billion budget request that you have, and we have included money specifically for a near-Earth object identification project and response project, as well as the Arecibo telescope, which is essential, absolutely essential if we are going to discover if there is a near-Earth object heading to the Earth, would that be agreeable to you?

Dr. GRIFFIN. Well, sir, if the Congress authorizes an activity and appropriates funds for it and the President signs that law, then, of course, it is agreeable to me. I will carry it out. I mean, of course. We are within the parameters of our existing funding for near-Earth object surveys. We are doing that, and in fact, accelerating it slightly to meet the stated intent of Congress. Beyond the few million that we are spending on it, I can't go today because I have, again, neither Presidential direction, Congressional authorization, or appropriation. So——

Mr. ROHRABACHER. Well, those of us who think, who believe that this is a vital program and could well be important to the survival of the planet would, are going to try to work with you and make sure that you are not just given the responsibility but also have some extra resources for that.

Dr. GRIFFIN. Well, I, too, am quite interested in the near-Earth objects. So I would find it agreeable.

Mr. ROHRABACHER. And one last area, and that is I want to congratulate you for your strong stand on permitting the commercial, potential commercial servicing of station for both supplies and crews as a means of promoting technology development and also saving money. So thank you very much.

Dr. GRIFFIN. Thank you, sir.

Chairman GORDON. Thank you, Mr. Rohrabacher. And now Mr. Lampson is recognized.

SHUTTLE REPLACEMENT FUNDING AND SCHEDULE

Mr. LAMPSON. Thank you, Mr. Chairman.

Just to carry on from where I was a little while ago, just a quick question. We have had a lot of conversation about the gap, and the *NASA Authorization Act of 2005* directed NASA to develop and deploy an operational human space transportation system to replace the Shuttle as close to 2010, as possible. The Authorization Act indicates launching a crew exploration vehicle as close to 2010.

At any rate, what specific actions, if any, has the Administration taken to comply with that Congressional direction?

Dr. GRIFFIN. The budget request that the Administration has made provides sufficient funds at 65 percent statistical confidence to deploy Ares and Orion, the Shuttle replacement that you speak of, by March of 2015. And that is as close to the end of Shuttle retirement as possible with the level of funding that is allocated.

Mr. LAMPSON. Well, given the Congressional direction in the Authorization Act, has the Administration provided or why hasn't it provided any additional funding to the Constellation Program to narrow the space flight gap?

Dr. GRIFFIN. Well, clearly the Administration has not provided the funding to narrow that gap. I can't speculate as to why.

Mr. LAMPSON. Did NASA request additional funds to do so?

Dr. GRIFFIN. NASA has had many discussions within the Administration on this topic, and as I know that you know, we have many priorities, many funding priorities in the Nation, all of which clamor for first attention. And the funding, the priority of closing the gap between Shuttle retirement and deployment of new systems did not make it to the top.

Mr. LAMPSON. What do you consider to be the most realistic options for narrowing the gap?

Dr. GRIFFIN. Well, the most realistic option at this point would be, I hate to say it this way, but add money. We answered this question for your colleague, Senator Nelson, on the record last November, and at this point about the earliest achievable date, again, the earliest technically credible date that I could sign up to would be the fall of 2013, say September of 2013, and we would need a billion dollars extra in '09, and a billion dollars in '10, to do that, for a total of about two billion, as best we can tell today.

With the past decisions that have already been taken and which are behind us, I can today not—I cannot credibly promise anything earlier than 2013, at this point.

Mr. LAMPSON. Was that put on the table in this budget process? Was that request specifically made? Because the law says do it as close to 2010 as possible, '13 is closer than '15, and if that is the wishes of Congress, did the President consider or did you consider or how——

Dr. GRIFFIN. Well, I certainly considered it, and I cannot go into all of the discussions and debates that have been held within the Administration as part of the process to generate a budget request, but certainly we worked very hard to understand what was needed,

which was why I was able to give that answer to Senator Nelson on the record, and again, that priority was not judged to compete with other priorities that the Nation has.

Mr. LAMPSON. Would a billion dollars at this point move it, move that date to 2013, or what is the——

Dr. GRIFFIN. Well, the rate of progress is roughly one month for $100 million. Okay. Roughly. Now, and, again, $2 billion then should equal 20 months but actually equals about 20 months actually from where we are. So that is the way to judge it. It is—you can buy additional progress at about $100 million per month.

Mr. LAMPSON. Thank you very, very much, and Mr. Chairman, I will yield back my time. Thank you.

Dr. GRIFFIN. Again, we have answered all that for your colleague.

Mr. LAMPSON. Thank you.

RUSSIA AND THE GAP

Chairman GORDON. And Ms. Patterson, we thank you for your attention and attendance here today, and Mr. Udall, let us see. I guess I should go to—Mr. Rohrabacher, I understand that you have a clean-up question?

I think that is where we are. Actually, we are——

Mr. ROHRABACHER. Well, thank you very much. I want to focus on your, the subject area of Russia and payments to Russia and the complications that we face.

Right now we are, of course, dependent on Russia during this period, the gap.

Dr. GRIFFIN. Yes. That is correct, sir.

Mr. ROHRABACHER. Okay. And I think you said it was $100 or $700 million worth of contracts. Is that right?

Dr. GRIFFIN. The current contract has a total value of about $780 million, and that expires in—at the end of 2011.

Mr. ROHRABACHER. Right. And you would expect that we need to have another contract?

Dr. GRIFFIN. I do if we are to utilize the station.

Mr. ROHRABACHER. And what would that contract, how much would that contract be for?

Dr. GRIFFIN. Well, I don't know yet.

Mr. ROHRABACHER. You don't know.

Dr. GRIFFIN. Because we haven't had those discussions with our Russian partners but——

Mr. ROHRABACHER. But we need——

Dr. GRIFFIN.—for a similar level of performance it is unlikely that it would be less than today's value.

Mr. ROHRABACHER. Right. And the legislation and legislative help that you need in order to, we need to pass some legislation right now, and you might, if you could alert us to that, what we need to do to facilitate.

Dr. GRIFFIN. The Administration needs to come forward with a formal request. As I said earlier, my remarks today are in the nature of a heads up, that I am working this within the Administration, but that the Congress needs to grant an exemption to NASA from Iran, North Korea, Syria Non-Proliferation Act. That is the action that would be required later this year.

Mr. ROHRABACHER. Having worked on that legislation, I think I put some weasel words into the legislation that might be interpreted by a lawyer to be able to get us out of a mess like that. Have your lawyers determined that those weasel words were not adequate enough to help you out of this problem?

Dr. GRIFFIN. Well, the—I am not an attorney, but our attorneys within the Administration, our attorneys' understanding of that as you put it, weasel word, is it applies to an emergency——

Mr. ROHRABACHER. Right.

Dr. GRIFFIN.—of a highly-temporary nature. So, for example, if we needed to pay to get crew off the station in an emergency during a time period that wasn't covered by the exemption, we could do that, but we could not open up a multi-year procurement for the delivery of goods and services to the station along the lines of the contract we have today. Your weasel words are inadequate to approve that.

Mr. ROHRABACHER. Sorry about that. One last note. The—I, again, I commend you for your creative approach to the re-supply station, which includes this opening up to commercial bidding for services for both supply and for crew, that same approach in terms of offering contracts or giving reward to the private sector for developing alternatives to having something done within NASA itself, I have, as you know, a piece of legislation aimed at establishing a national endowment, which would provide prizes, we need to provide prizes for the development of new technologies that could be useful to NASA and aerospace in general.

Do you have any thoughts on that legislation?

Dr. GRIFFIN. Not in any sort of detail that I would——

Mr. ROHRABACHER. Okay.

Dr. GRIFFIN.—want to air here. Broadly speaking I think that the prize activity that we have seen so far has been very promising and certainly gets, brings attention to space. I hope that it can be found to have some longer-lasting value as well.

Mr. ROHRABACHER. It seemed to me that if we should, if we see something that works and seems to have been of value, that we could expand upon it, and the whole prize notion serves the taxpayers well because you don't have to pay off unless someone has actually achieved what is laid down as the purpose of the prize.

WATER ISSUES

So thank you very much again for your great leadership at NASA, and I have one other question that my staff was looking for.

Western Governors have—they are looking at—they are worried that Landsat thermal infrared capabilities are not going to serve their interests looking at their water issues. Do you know anything about that?

Dr. GRIFFIN. I don't, sir. If you supply it for the record, we will answer it for the record. I—but I am unfamiliar with that concern. I am sorry.

Mr. ROHRABACHER. Yeah. One of the great paybacks that the space program has had for humankind and especially for the American people is our ability to help us make determinations as to where water resources should be used and how and some of our critical, you know, analysis of what is going on in the land from

space. So that is really something, whenever we can get a payback for the American people by helping them work their way, find the answers to water shortages, et cetera.

Thank you very much.

Chairman GORDON. Thank you, Mr. Rohrabacher. As we have discussed, this committee is going to be spending a lot of time this year looking at water and looking at how we can find efficiencies both in the industrial and the residential section.

And again, my apologies to Ms. Richardson for my block, and I think Mr. Udall is going to be our cleanup man.

THE NAOMS PROJECT

Mr. UDALL. Thank you, Mr. Chairman. Dr. Griffin, if I might, I would like to turn back to discussion about NAOMS. I got a series of questions I would like to direct your way and then ask you to answer the questions.

Do you plan to make any additional data releases beyond what is already been made public? What is the current status of your plan to have the Academies review, National Academies, that is, the NAOMS Project, and have they started their review, what specifically have you asked the Academies to do? When do you anticipate that the review would be completed, and do you have any plans to revisit the decision to terminate the NAOMS Project, and if so, when?

Dr. GRIFFIN. I will try to remember all those questions, and I will ask you for help if I screw up.

With regard to plans to resume NAOMS, no. We have no plans to resume NAOMS. We think that all of the goals of NAOMS with regard to aviation safety are being accomplished in coordination with the FAA on, with ongoing programs. So it is not that we don't like those goals, we think we are pursuing them outside of the context of NAOMS.

We do plan additional data releases this year. We provided a heavily-redacted version to meet my end-of-the-year commitment on New Year's Eve. I am sorry for that. It was the best we could do. We have named a program manager at the Glenn Research Center. That program manager will report directly to the office of the Administrator at NASA. The purpose of that effort for that program manager will be to draft and issue a request for proposals from various firms to, with an appropriate statistical data redaction capability to go over the NAOMS survey data and appropriately redact confidential commercial information and to protect respondent anonymity while releasing the maximum possible intellectual content in the data.

When I talk about the data, again, this is a matrix of data, 29,000 rows by several hundred columns. So it is an enormous amount of data. We must be very certain that we don't compromise individual identities and that we don't release voluntarily-supplied commercially-confidential information.

The original contractor on the NAOMS study was supposed to do that, but as I pointed out in prior hearings, we have found cases where that was not done, and we need to be more careful before we release it.

You asked about the—but we will provide staged releases over the course of the year as the data is studied. We will do it as often as we can, and we will keep you informed.

Now, the un-redacted data, I know that the Congress is furnishing that to the GAO to allow its assessment of the potential utility of the NAOMS data, and I applaud that. Additionally, we are working with the National Research Council, National Academies, as you mentioned. We would like them to examine the data for its potential utility. NASA has been criticized for saying that we don't see much utility to this data and have moved on with other programs with the FAA, but in case we are wrong, I would like to have the National Academy take a look at the un-redacted data and judge for, judge independently if there is value in it.

To do that initially has been a bit of a problem because our early inputs from the Academy were that any data which comes to them has to be released publicly. That, of course, is not possible. However, the people who were making those statements weren't attorneys, and it turns out that when their attorneys and ours have spoken, that they believe they have a way forward to treat this data with appropriate confidentiality, which is necessary while assessing it in its un-redacted form for potential utility. And if that works out, then I will be very happy.

Mr. UDALL. Do you have a sense of the timeline?

Dr. GRIFFIN. That will occur over the course of this year. I cannot, I mean, the National Academy takes the time it takes, and in my prior experience getting anything out of them in much less than a year is not feasible. So I would say over the course of this year as soon as reasonably possible.

Mr. UDALL. Thank you, Dr. Griffin.

MARS SCIENCE LABORATORY

Mr. Chairman, if I might, I would ask a final question seeing my time is about to run out for the record, and I want to turn back to the New Earth Science and Space Science missions that have been proposed.

As I said in my initial statement, I am excited to see where that leads us. I am concerned about the price tags that are associated with them, and I wanted to direct a general question, which is why should we be confident that NASA can actually carry out the proposed new missions under the science budgets assumed for the future? And especially using the Mars Science Laboratory, the MSL, as an example, that is is supposed to be launched next year. It is facing, as I understand it, new development problems, although it was subject to a serious review not that long ago.

I know the Committee would be interested in knowing what the problems of the MSL are, how serious are they, and what we can do to fix them. And then how confident are you that we will be able to meet its '09 launch date and then more broadly, what steps is NASA taking to insure that the same types of problems that have afflicted MSL don't afflict the proposed new missions.

Dr. GRIFFIN. Do you want me to answer now or for just the record?

Mr. UDALL. I would defer to the Chairman as to how much time we have left and would certainly be more than happy with comments for the record or right now.

Chairman GORDON. If you want to summarize and then you can provide additional information for the record.

Dr. GRIFFIN. We will answer in full for the record. Let me give you a quick summary. MSL is having heat shield problems. Our earlier assumption on using what we call SLA, super lightweight ablative, like we use on the Shuttle external tank, that it would make an adequate heat shield for MSL did not survive actual tests. So we are going to a material called pica, which is a stronger ablator. That is going to cost several tens of millions of dollars.

In addition, there are, I would not say other developmental problems, but just increased costs. Things have gone more slowly than we would like. We still believe at this point that we can make the September of '09 launch date. If that changes, we are looking at options to launch in '10, and options to launch in '11.

So, Mars Science Lab is a flagship mission in the Mars Program. It is very crucial to us. It is something that has never been done before. I mean, development problems are to be expected, and I don't honestly consider that the problems they are having are, I wouldn't call them out of family. I have great confidence in the Mars Science Lab Team. I really do, which is not to say that they aren't overrunning some, and we are going to have to figure out a way to deal with that. And we will give you a more complete answer on the record.

Mr. UDALL. Thanks, again, Dr. Griffin, for being here today.

Dr. GRIFFIN. Thank you, sir.

POTENTIAL USE OF CHINESE LAUNCH CAPABILITIES

Chairman GORDON. It appears that Mr. Rohrabacher has one more question.

Mr. ROHRABACHER. I don't want to take up Mr. Baird's time unless—well, thank you.

Just very quickly. I certainly am supportive of what you have outlined for us today about the need for cooperation with Russia, and I think that the cooperation with Russia has served America's interest.

Dr. GRIFFIN. I do, too, sir.

Mr. ROHRABACHER. I would suggest on the other hand that cooperation with China has not served our interest. In fact, we have learned a lot from the Russians, and in fact, every time we have cooperated in space with the Chinese they have basically stolen our technology, and we see them knocking our, or knocking satellites out of the air.

Is there at this time any plan to permit American satellites to be launched on Chinese rockets or any other type of cooperation with the Chinese government?

Dr. GRIFFIN. I don't know, sir. I have no such plans, but I don't know what other entities may be planning.

Chairman GORDON. Thank you, Mr. Rohrabacher. Before we bring the hearing to a close, I want to thank our witness for testifying before the Committee today. The record will remain open for

additional statements from the Members and for answers to any follow-up questions the Committee may ask of the witnesses.

The hearing is now adjourned.

[Whereupon, at 11:55 a.m., the Committee was adjourned.]

Appendix 1:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Michael D. Griffin, Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Chairman Bart Gordon

Q1. In material requested for the record from the Space and Aeronautics Subcommittee on July 24, 2007 entitled "NASA's Space Shuttle and the International Space Station Programs," Associate Administrator Bill Gerstenmaier was asked what NASA would do if neither the Commercial Orbital Transportation Services (COTS) capabilities nor non-U.S. vehicles (ATV–Europe, HTV–Japan) were available to meet NASA's logistics schedule for ISS. In his reply, Mr. Gerstenmaier stated that NASA "has strategies to react within the appropriate timeframes if the development does not proceed per schedule."

Q1a. What are these strategies?

A1a. NASA envisions a mixed fleet strategy to support Space Station cargo requirements, with a strong preference toward U.S. commercial services. If neither COTS nor non-U.S. vehicles are available to meet logistics needs for operating and maintaining the ISS, NASA would have to actively and aggressively manage spacecraft systems degradation in a manner that minimizes the probabilities of loss of systems and loss of vehicle until such time as the needed transportation services become available. The ISS partnership took similar measures during the period when the Shuttle was grounded following the *Columbia* accident to minimize logistics needs, so NASA has experience in operating with transportation constraints. It should be noted that progress continues to be made in the COTS program, with a newly funded Space Act Agreement signed. With regard to logistics support for the Station, NASA recently released an RFP for commercial resupply. In addition, the European ATV has recently demonstrated a successful docking to the ISS, and in doing so delivered 1,150 kg of dry cargo, as well as propellant, oxygen and water.

Q1b. How would NASA go about implementing these strategies?

A1b. The prioritizing and pre-positioning of system spares minimizes International Space Station systems degradation. This may be augmented by successful execution of the two contingency flights if they can be accomplished before retirement of the Space Shuttle in 2010. In addition, NASA would take measures to closely monitor and manage consumables.

Q2. Has NASA made any changes across the agency to the requirements for background investigations for HSPD–12 rebadging while a pending lawsuit continues? Has NASA changed the timetable for compliance? What is the status of the HSPD–12 program at each of the Centers?

A2. NASA continues to implement HSPD–12 in accordance with regulations and guidance applicable to all federal executive departments and agencies. Badging compliance within NASA continues to progress toward successful rebadging by October 27, 2008, as required.

The litigation to which you allude, filed with the United States District Court, Central District of California, involves 28 contractor employees at the Jet Propulsion Laboratory (JPL) in California, out of a working population of about 8,000. To date, no other NASA employees, contractors, or locations are directly involved. The lead agency in the litigation is the Department of Justice, which represents NASA and other involved federal agencies in court.

The District Court has issued a preliminary injunction and, subsequently, provided additional guidance to clarify the injunction. In accordance with the Court's clarification, NASA will begin issuing badges to JPL employees whose investigations have been completed (not including the 28 named plaintiffs). JPL employee background investigations which are not yet complete have been halted, which is also in accordance with the Court's clarification. NASA will continually monitor HSPD–12 compliant badging measures at JPL to ensure they remain in compliance with any future Court rulings.

NASA will comply fully and promptly with applicable court orders as interpreted by and advised by the Department of Justice. The processing and outcome of this litigation is within the federal judicial system and, therefore, further comment by NASA would not be appropriate.

Q3. In answering a question for the record in last year's hearing, NASA told the Committee that as Constellation System Requirements Reviews (SRR) are com-

pleted, it would gain a clearer understanding of the demands for future workforce skills, thus forming the foundation for making future decisions on the appropriate numbers and mix of skilled workers needed to safely fly the Shuttle through 2010 and to transition to the CEV. Now that the SRRs have been completed, when do you expect to provide the numbers and mix of skilled workers needed to complete the Shuttle flights and transition to CEV?

A3. NASA is focused on managing the evolution from current operations of the Space Shuttle to future operations of Constellation and emerging commercial services, in a safe, successful and smooth manner. This joint effort between the Space Operations and Exploration Systems Mission Directorates includes the utilization and disposition of resources, including real and personal property, personnel, and processes, to efficiently leverage existing Shuttle and Space Station assets for future Exploration activities, including the Orion Ares I, and Ares V projects. NASA is managing human space flight workforce issues within the broader context of the Agency's transition activities, described in the *NASA Human Space Flight Transition Plan.* To augment these transition processes and ensure close cooperation and partnering between NASA and industry, a Human Capital Council comprised of human resources directors from the prime contractors and Centers has been formed and meets quarterly. Supporting the efforts of the Human Capital Council, NASA and its prime contractors conduct frequent formal and informal Technical Interchange Meetings including a broad range of participants. NASA also tightly integrates transition workforce planning into its acquisition and budget development activities.

In addition to contract awards, Constellation workforce requirements maturation has provided more clarity and better insight into future workforce and skill mix needs. This information, combined with updated Shuttle workforce analysis and more refined Transition and Retirement requirements, forms the basis of workforce information included in the NASA Workforce Transition Strategy submitted to the Subcommittee on March 31, 2008. This report will be updated and submitted to the Congress every six months. We expect to have further refinement of workforce numbers and skill requirements in NASA's FY 2010 budget submit, and will continue to take place through subsequent annual budget preparation processes.

Q4. Dr. Griffin, your testimony indicates that "$2.6 billion in NASA funds [is] available over the next five years to purchase cargo and crew services to support Space Station operations." What portion of those funds is encumbered to purchase crew and cargo services provided by the Russians through 201I?

A4. Of the approximately $2.6B in NASA funds budgeted from FY 2009 through FY 2013 to purchase cargo and crew services to support the International Space Station, approximately $589M is budgeted for Russian services from FY 2009 through FY 2012 (note: NASA is permitted to purchases Russian services through the end of calendar 2011—the beginning of FY 2012).

Q5. Dr. Griffin, NASA is conducting educational activities in parts the Science Mission Directorate, for example, in addition to the programs included in the agency's Education office. What are NASA's goals, across the agency, for education? What steps is NASA taking to maximize the effectiveness of the agency's investments in education, including how these investments relate to science, technology, engineering and mathematics (STEM) education?

A5. NASA's Agency goals in education are outlined in both the 2006 *NASA Strategic Plan* and the *NASA Education Strategic Coordination Framework: A Portfolio Approach.* In 2006 and beyond, NASA will pursue three major education goals:

- *Strengthen NASA and the Nation's future workforce*—NASA will identify and develop the critical skills and capabilities needed to ensure achievement of NASA's mission. To help meet this demand, NASA will continue contributing to the development of the Nation's science, technology, engineering, and mathematics (STEM) workforce of the future through a diverse portfolio of education initiatives that target America's students at all levels, especially those in traditionally under-served and under-represented communities.
- *Attract and retain students in STEM disciplines*—NASA will focus on engaging and retaining students in STEM education programs to encourage their pursuit of educational disciplines and careers critical to NASA's future engineering, scientific, and technical missions.
- *Engage Americans in NASA's mission*—NASA will build strategic partnerships and linkages between STEM formal and informal education providers. Through hands-on, interactive educational activities, NASA will engage stu-

dents, educators, families, the general public, and all Agency stakeholders to increase Americans' science and technology literacy.

All of NASA's education efforts are part of an integrated Agency-wide approach to human capital management. Within the NASA Strategic Plan, education is identified as a crosscutting function that supports all of the Agency's strategic goals and objectives.

NASA will continue the Agency's tradition of investing in the Nation's education programs and supporting the country's educators who play a key role in preparing, inspiring, exciting, encouraging, and nurturing the young minds of today who will manage and lead the Nation's laboratories and research centers of tomorrow. As the United States begins the second century of flight, the Nation must maintain its commitment to excellence in STEM education to ensure that the next generation of Americans can accept the full measure of their roles and responsibilities in shaping the future.

Questions submitted by Representative Mark Udall

Q1. Last November, Ernst & Young (E&Y) disclaimed an opinion on NASA's financial statements for the fiscal years ended September 30, 2007 and 2006. The disclaimer resulted from NASA's inability to provide E&Y auditable financial statements and sufficient evidence to support the financial statements throughout the fiscal year and at year-end. What seems to be the problem in NASA receiving a clean opinion? Are you satisfied that you are on your way to securing a clean opinion? When do you project NASA will receive a clean opinion?

A1. Toward the objectives of obtaining an unqualified opinion and eliminating material weaknesses in internal controls, NASA has developed a Comprehensive Compliance Strategy (CCS) that focuses on ensuring compliance with Generally Accepted Accounting Principles (GAAP) and other financial reporting requirements. The CCS also covers the standards and requirements necessary to cure deficiencies noted in recent audit and related reports. The CCS serves as the basis for implementing comprehensive proactive corrective actions and provides the guiding principles for executing effective financial management functions and activities with internal control and compliance solutions inherently embedded in the processes.

In the first quarter of FY 2008, NASA undertook an internal review and engaged a nationally-recognized accounting firm to perform an in-depth analysis of requirements for NASA to be in compliance with GAAP and other applicable financial standards, to demonstrate such compliance through auditable evidence, and to operate with robust and comprehensive internal controls. Validation of this framework and plans to implement the required actions to conform NASA policies and procedures to this framework were completed in the second quarter of FY 2008. An assessment of the remedial actions necessary is underway, and upon completion of the assessment, timing and phasing for resolution will be determined. The CSS provides the critical path milestones for NASA to resolve the FSAO material weakness.

The Property, Plant and Equipment material weakness is comprised of issues primarily related to the agency's reliance on contractors to "report property values at periodic intervals without robust agency-wide detect controls," and difficulties ensuring the completeness of balances for certain legacy assets.

In November 2007, NASA implemented a new policy and related procedures for identifying the cost of individual assets throughout the asset's acquisition life cycle. This policy change was based on guidance received from the Federal Accounting Standards Advisory Board (FASAB). These changes support the verification and reconciliation of asset values for those assets developed through new contracts (post November 2007) and certain large preexisting contracts. For legacy assets, like the Space Station and Space Shuttles, NASA does not have the necessary supporting information available to provide auditable book values for the Space Shuttle and the International Space Station (ISS). Together, Shuttle and ISS related assets currently represent over $14.0B of the total $20.6B PP&E net asset value reported in the September 30, 2007 fiscal year-end financial statements. While certain of the existing Shuttle and ISS assets will be transitioned for use on other NASA programs, much of this issue may become moot with the passage of time, as the Shuttle is to be retired in 2010, and the ISS is being depreciated based upon a 15-year specification life through 2016. While the ISS depreciation schedule naturally leads to 2016 as an outside date for resolution of this issue, NASA is presently developing and evaluating a variety of alternatives with a view to achieving a more timely, albeit still cost efficient and effective, solution for this issue.

Q2. E&Y identified two significant deficiencies, which are considered to be material weaknesses. Material weaknesses were found in NASA's controls for (1) financial systems, analyses, and oversight used to prepare the financial statements, and (2) assuring that property, plant, and equipment and materials are presented fairly in the financial statements. These material weaknesses have been reported for several years. NASA recently appointed a new CFO. What expectations have you placed on the CFO to correct these long standing material weaknesses?

A2. Toward the objectives of obtaining an unqualified opinion and eliminating material weaknesses in internal controls, NASA has developed a Comprehensive Compliance Strategy (CCS) that focuses on ensuring compliance with Generally Accepted Accounting Principles (GAAP) and other financial reporting requirements. The CCS also covers the standards and requirements necessary to cure deficiencies noted in recent audit and related reports. The CCS serves as the basis for implementing comprehensive proactive corrective actions and provides the guiding principles for executing effective financial management functions and activities with internal control and compliance solutions inherently embedded in the processes. A key component of the compliance process is NASA's newly developed Continuous Monitoring Program (CMP) which provides the overall framework of management controls that NASA uses to assess and evaluate its (i) internal controls, (ii) compliance with Generally Accepted Accounting Principles (GAAP), and (iii) evidence that balances and activity reported in its financial statements are auditable (accurate and complete). The CMP ensures that ongoing management reviews and validations of financial data, financial statements and internal controls are performed when and as required.

NASA's Chief Financial Officer, Hon. Ronald R. Spoehel, joined the Agency in September of 2007 and has led efforts to resolve the Agency's long-standing material weaknesses. But more than just focusing on correcting past weaknesses, Mr. Spoehel has refocused these efforts toward a comprehensive compliance strategy proactively promoting ongoing, full compliance by NASA with legal and regulatory requirements for financial reporting. Supporting this strategy is the aforementioned comprehensive monitoring program that provides insight into issues as they arise and into the steps being taken to resolve those issues.

Q3. Last year, NASA attributed the absence of an Enterprise Architecture and an Integrated Work Plan for the Next Generation Air Transportation System to the lack of agreement among JDPO member agencies on specific gap needs and how they need to be addressed. Now that both documents cited by NASA have been issued, are we closer to a better refined technical roadmap and resource plan? In your view, how can we optimize NASA's contribution to developing the next generation Air Transportation System?

A3. NASA's aeronautics research is aligned with the goals of the National Aeronautics Research and Development Policy, the National Plan for Aeronautics Research and Development and Related Infrastructure, the findings and recommendations of the National Research Council Decadal Study, and the planning documents for Next Generation Air Transportation System (NextGen) as created by the Joint Planning and Development Office (JPDO).

NASA's Aeronautics Research Mission Directorate (ARMD) has worked closely and diligently with the JPDO member agencies in the development of the NextGen R&D Plan and has come to agreement on the plan elements and specifically the ARMD contributions. Version 1 of the R&D Plan was completed in 2007; however, it is presently being incorporated into the Integrated Work Plan (IWP) which currently remains a draft document. The IWP will include comprehensive coverage of the NextGen operational improvements, roadmaps, as well as the R&D plan. The JPDO has initiated an effort on March 13, 2008, to conduct a gap analysis to reexamine potential R&D gaps in the context of the IWP including updated roadmaps and operational improvements. NASA ARMD is collaborating directly with the JPDO as part of a multi-agency team to conduct this assessment. As the IWP further matures, ARMD's research programs will review their investment portfolios to ensure the most appropriate support for NextGen.

Q4a. Dr. Griffin, at a hearing on Near-Earth Objects held by the Subcommittee on Space and Aeronautics in the fall of 2007, expert witnesses testified on the need for the planetary radar capabilities of the Arecibo Observatory to characterize potentially hazardous near-Earth objects in a timely fashion. NASA officials recently told Committee staff that NASA does not need the Arecibo Observatory and that optical telescopes can provide any necessary data. The language accompanying the FY 2008 Omnibus appropriations states that "NASA is directed to provide additional funding for the Arecibo Observatory." *How does*

NASA plan to comply with the Congressional direction to provide funding for Arecibo?

A4a. NASA has committed $538,110 of FY 2008 planetary science funding to researchers that are using the Arecibo radar facility for planetary science, including NEO characterization efforts. No NASA funds were provided directly for Arecibo facility operations. Arecibo is operated by a NSF-funded FFRDC.

Q4b. Could you please elaborate on NASA's position on Arecibo?

A4b. The President's budget request for NASA supports researchers that use the Arecibo radar facility for planetary science, including NEO characterization efforts, but does not provide funds for Arecibo facility operations. Arecibo is operated by an NSF-funded FFRDC. Should Arecibo capabilities be reduced or the facility be closed, NASA will be able to continue its work using other capabilities available within the Agency's Deep Space Network or other available facilities.

Q4c. Has NASA met with NSF on the future of Arecibo?

A4c. Yes, NASA and NSF managers have met on this issue twice in the past year. The future of Arecibo has also been openly discussed by NASA and NSF representatives to NASA' and NSF-funded science researchers at a recent meeting in March 2008 at the National Academy of Sciences.

Q5. Does NASA have a back-up plan should the Deep Space Network operations break-down before a new system is in place? If so, could you please provide a copy of that plan?

A5. There is no risk of a complete "break-down," so there is no back-up plan for a Deep Space Network (DSN) operations break-down. Rather, the critical nature of DSN operations is protected with multiple redundancies that enable a high reliability for all critical operations of NASA spacecraft, as measured by performance metrics requiring 95 percent network availability. Actual performance is approximately 99 percent. All maintenance and operations activities, including those targeting obsolete equipment, are designed to maintain the redundancy that ensures this availability, and no plans are underway to reduce this performance requirement. The DSN consists of three deep-space communications facilities placed approximately 120 degrees apart around the world: at Goldstone, in California's Mojave Desert; near Madrid, Spain; and near Canberra, Australia. Each DSN facility consists of at least four deep space stations equipped with ultra-sensitive receiving systems and large parabolic dish antennas (34-meter High Efficiency and Beam Waveguide antennas, as well as 26-meter and 70-meter antennas). Later this year the DSN will produce a document that will provide a plan to keep the DSN operational to the 2020's.

Questions submitted by Representative Charlie Melancon

Q1. My district is close to the Michoud facility, which provides jobs for many people in my district. This facility has played a large part in the assembly of the Space Shuttle. Recently a contract to start assembling parts of the Constellation system was awarded for the Michoud facility. To continue sustained work in Michoud, there needs to be no or a minimal gap between these two programs. In your briefing materials, you indicate that the Shuttle program will be retired in 2010. In 2009, you expect the Orion and Ares I production and operation to commence.

Q1a. When do you expect to complete assembly of the Shuttle program?

A1a. The last Space Shuttle mission is planned to be launched by September 30, 2010. NASA will assemble enough Space Shuttle External Tanks at the Michoud Assembly Facility (MAF) to fly the Shuttle safely and maintain critical workforce skills through the end of the Space Shuttle program.

Q1b. Currently most of the work completed in Michoud is at a minimal staff, prototype level, correct?

A1b. No. The same External Tank (ET) production line is in place and certified to produce the hardware.

MAF will complete production of External Tanks for the Space Shuttle in 2010. Starting in 2008, MAF begins preparations to start production assembly of upper stage tanks by Boeing for the Ares I launch vehicle. Lockheed Martin plans to use MAF for selected Orion Primary Structure production. NASA will select a new multi-program Facility Operations and Maintenance contractor in early FY 2009; NASA is still studying the scope and work required to conduct that function for all

the NASA programs which will use MAF. Production and test of the Ares V Core Stage and Ares V Earth Departure Stage will begin ramping up in FY 2011; NASA is still studying the tasks and contracts for Ares V work. NASA is considering early Ares V risk reduction and skill retention manufacturing tasks at MAF, but in 2008, these are only being evaluated for a later decision. Work required at MAF to retire the Space Shuttle External Tank production after 2010 is still under study.

Q1c. When do you expect operations to return a level similar to that of the Shuttle assembly?

A1c. There will be a ramp down from External Tank production and a ramp up for Orion primary structure and Ares I Upper Stage work, but total facility utilization will not be the same as ET production until the lunar elements (Ares V Core Stage, Earth Departure Stage) ramp up around 2015.

The development schedule for the Constellation program is paced in large part by available resources—primarily annual appropriated budgets, but also by technology readiness, and the availability of skilled workforce and unique facilities.

Q1d. To help bridge the workforce gap, are there any efforts underway to accelerate work on the Ares V program—either through early risk mitigation studies or conceptual design development?

A1d. Yes, both of these are being considered; however, requirements maturity, funding availability, and workforce availability are the driver elements. Congressional support for NASA's full FY 2009 budget request will help ensure stable and adequate funding so that an effective workforce transition will be implemented based upon dynamic, yet relatively predictable programmatic and mission requirements. Awarding lunar contracts on the schedule supported by the FY 2009 budget request provides evidence of emerging opportunities, reduces workforce concern and uncertainty about the impending human space flight gap, and facilitates workforce strategy development and mitigation plans.

Q1e. Can you discuss what steps NASA is taking to ensure we don't lose our highly skilled technical workforce in this region?

A1e. NASA is considering component production for additional External Tank elements as both a flight manifest risk reduction activity and a critical skills retention activity. Additionally, NASA is considering early Ares V beneficial activities and skills bridging or retention activities. The Agency is also completing specific workforce and skill mix requirements and availability analyses. Collectively, these will drive the forward decision-making in this area.

As NASA reaches the end of the Space Shuttle Program, specific Space Shuttle contract actions will be used to retain workers needed for Space Shuttle even as new Constellation work is competed with industry. NASA is assisting in the development and implementation of contract workforce retention plans for each Space Shuttle prime contractor, with a focus on communication and future work. Several of the four prime contractors are implementing monetary retention incentives. As appropriate, the contractor community is using a range of tools, such as cross-training, to demonstrate a future path for employees, as well as embedding personnel with operational experience in the design phases of Constellation's vehicles.

Q2. Currently, Michoud manufactures the Space Shuttle External Tank.

Q2a. What role will Michoud play in the Constellation system?

A2a. MAF will play a critical role as a multi-project strategic production facility for Constellation. Orion and Ares I Upper Stage prime contractors currently plan to use Michoud. The Constellation Program has future plans for production of Ares V Core Stage and the Earth Departure Stage at MAF.

Q2b. How much as been allocated to award contracts at Michoud?

A2b. Contracts for Orion and Ares I Upper Stage production have been awarded to Lockheed Martin and Boeing, respectively. Those contracts have some work being performed at Michoud, such as manufacturing of the Orion primary structure and upper stage core and instrument unit ring, as well as other locations around the country. The contract structure does not allocate funding for a particular location, but rather an end item.

Q2c. Can you provide me your best estimate on approximate workforce numbers for the Michoud facility on the Orion, Ares I and Ares V programs in the coming years?

A2c. Due to the recent award of the Boeing Upper Stage Contract and recent plans by Lockheed Martin to bring additional design work to Michoud, the estimates are dynamic and not yet available. Additionally, this year, the new Michoud Maintenance and Operations contract will be awarded, further driving the workforce estimate. Preliminary workforce estimates are included in the NASA Workforce Transition Plan submitted to the Subcommittee on March 31, 2008. This report will be updated and submitted to the Congress every six months.

Q3. NASA remains on Government Accountability Office (GAO's) "high risk" list for contract management practices, and an independent audit for FY 2007 found that NASA's financial management systems are not substantially compliant with the Federal Financial Improvement Act of 1996.

Q3a. How will this affect NASA's ability to enter into contracts to begin development and construction for the Constellation modules?

A3a. NASA's status on the GAO High-Risk List will not impact the Agency's ability to enter into contracts. NASA's High-Risk Corrective Action Plan seeks to improve the effectiveness of its program/project management across the board, including monitoring and analyzing contractor performance; life cycle cost/schedule management practices; cost estimating practices; and associated business processes.

Q3b. How will this affect NASA's ability to effectively execute the Enhanced Use Leasing authority it is seeking from Congress?

A3b. NASA's status on the GAO High-Risk List will not impact the Agency's ability to effectively execute the Enhanced Use Leasing authority. NASA's High-Risk Corrective Action Plan seeks to improve the effectiveness of its program/project management across the board, including monitoring and analyzing contractor performance; life cycle cost/schedule management practices; cost estimating practices; and associated business processes.

Questions submitted by Representative Charles A. Wilson

Q1. While NASA acknowledges that assuring the safety, health and performance of astronauts is critical to the success of the Exploration Systems Mission, funding for the Human Research Program has been dramatically reduced in recent years with no significant growth in funding requested for FY 2009 and beyond. It remains hard to reconcile this funding plan with the criticality of keeping and maintaining the health and safety of our astronauts. The issue on the current Shuttle mission to the International Space Station illustrates the importance of astronaut health to mission success. What is NASA's plan and funding, particularly for Human Health Countermeasures and Exploration Medical Capability, to develop the necessary understanding of the effects of zero and partial gravity environments on humans, develop and verify effective countermeasures, retire risks, and deliver required medical care to astronauts on exploration missions?

A1. NASA believes that crew safety, health, and performance is the Agency's highest priority and will ensure that adequate resources are available to address the human health risks associated with our nation's exploration missions. To that end, NASA's Human Research Program (HRP) has developed a risk-based management approach to assess all human health risks associated with the planned architecture for exploration missions. These risks were baselined in the *HRP Program Requirement Document* in May 2007, and are currently being reviewed by the Institute of Medicine of the National Academies. By addressing the risk-associated gaps in knowledge, technology, and countermeasures in a time-phased manner, HRP will mitigate and retire these risks as required to meet the exploration mission plans.

Using these risks and gaps as the framework, the program ensures that appropriate resources are allocated to tasks to address gaps and in-turn to mitigate human health risks associated with space exploration. Based on its Integrated Research Plan established in December 2007, HRP's assessment is that there is sufficient funding to address all near-term gaps in knowledge, technology, and countermeasures associated with the return to the lunar surface. If through further analysis it becomes evident that there is a budget shortfall in any of the identified human health risks, NASA will take immediate steps to address this resource issue to protect crew health and safety.

Regarding the Human Health Countermeasures and Exploration Medical Capability areas of research, HRP has identified the following human health risks associated within these areas:

- Risk of Accelerated Osteoporosis

- Risk of Orthostatic Intolerance During Re-Exposure to Gravity (dizziness, fainting)
- Risk of Inaccurate Assessment of Cardiovascular Performance
- Risk Factor of Inadequate Nutrition
- Risk of Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems
- Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance
- Risk of Operational Impact of Prolonged Daily Required Exercise
- Risk of Bone Fracture
- Risk of Invertebral Disc Damage
- Risk of Renal Stone Formation
- Risk of Cardiac Rhythm Problems
- Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity
- Risk of Crew Adverse Health Event Due to Altered Immune Response
- Risk of Impaired Ability to Maintain Control of Vehicles and Other Complex Systems
- Risk of Therapeutic Failure Due to Ineffectiveness of Medicine
- Risk of Inability to Adequately Treat an Ill or Injured Crew Member

HRP is currently funding tasks that address the mitigation of risks associated with Human Health Countermeasures and Exploration Medical Capability. Examples of tasks that are providing significant progress include the following:

- HRP has recently completed ISS data collection on a countermeasure to mitigate the risk of renal stone formation
- HRP has recently completed an Antarctic nutrition study on efficacy of Vitamin D supplementation using the Antarctic ground facility as an analog for space flight. This study undertaken jointly with the National Science Foundation, measured the dose of vitamin D needed to reach and maintain a desirable vitamin D status in the absence of sunlight
- HRP uses the ISS as a research platform to understand the effects of long-duration space flight on humans and to develop/test countermeasures that reduce the medical risks of human space flight. HRP is currently undertaking or developing ISS research that addresses Accelerated Osteoporosis, Orthostatic Intolerance, Altered Immune Response, Cardiovascular Performance, Inadequate Nutrition, Reduced Aerobic Capacity, Cardiac Rhythm Problems, Inability to Adequately Treat an Ill or Injured Crew Member, and Impaired Ability to Maintain Control of Vehicles and Other Complex Systems
- HRP is currently undertaking or developing research in its ground-based facilities, such as its joint bed-rest facility with the National Institutes of Health, that addresses: Accelerated Osteoporosis, Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance, Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems, Bone Fracture Risk, and Operational Impact of Prolonged Daily Required Exercise

In order to leverage resources to help ensure the timely development and validation of countermeasures and technologies, NASA and HRP partner with academia, other federal agencies (e.g., National Institutes of Health, Department of Energy), international space agencies (e.g., Canadian Space Agency, European Space Agency, Russian Space Agency), and private industries to mitigate the human health risks associated with exploration. HRP also uses national research announcements to provide an opportunity for universities, non-profit and commercial organizations to provide high-quality research that will directly benefit the Agency and create more effective research partnerships between NASA and the national biomedical research community. A key cooperative agreement is with the National Space Biomedical Research Institute (NSBRI), a consortium of 12 academic institutions from across the Nation. The goal of this important partnership is to conduct research to understand the effects of microgravity on humans, and to develop effective countermeasures to mitigate the risks associated with space flight. In support of NASA, NSBRI defines, selects and conducts external space biomedical research associated with human exploration risks for approximately 60 grants involving investigators at more than 70 institutions in 22 states across the United States. NASA/NSBRI steering committee and discipline teams jointly coordinated this research.

Finally, the research that HRP undertakes serves to inform the space flight health standards as maintained by the Office of the Chief Health and Medical Officer. These documents establish NASA's space flight crew health standards for the pre-flight, in-flight, and post-flight phases of human space flight. The Space Flight Health Standards for Human Performance apply to all NASA human space flight programs.

Q2. The Innovative Partnerships Program (IPP) provides technology solutions for NASA programs and transfers NASA technologies to the private sector for non-NASA applications. While the IPP budget remains essentially constant over the period FY 2009 to FY 2013, the funding for Technology Transfer Partnerships is estimated to decrease over this period in addition to reductions taken in prior fiscal years. In today's economic situation it is important to take every opportunity to stimulate the Nation's economy. What is NASA's plan for technology transfer to the private sector and what can be done to provide greater economic benefit from this critical function?

A2. All of the NASA IPP program elements contribute to increased commercial activity. Consequently, traditional "technology transfer out" is only one of several ways in which IPP contributes to the Nation's economic development. IPP consists of the following program elements: *Partnership Development,* which includes traditional Technology Transfer Out, Intellectual Property Management, and dual-use Technology Development Partnerships; *Technology Infusion,* which includes the IPP Investment Seed Fund and the Small Business Innovative Research (SBIR)/Small Business Technology Transfer (STTR) programs; *Innovation Incubator,* which includes Centennial Challenges as well as new initiatives such as facilitating the purchase of services from the emerging commercial space sector.

IPP's Technology Transfer Out function involves licensing of NASA technologies for commercial application and other public benefit. In FY 2007, IPP facilitated signing of 35 license agreements and 598 software use agreements. The Intellectual Property Management function enables the reporting of new NASA invention disclosures. As a result of IPP's FY 2007 and prior years efforts, over 100 NASA patent applications were filed and 93 patents awarded in FY 2007. The Intellectual Property Management function therefore complements the Technology Transfer Out function by facilitating protection of the technology that becomes the subject of NASA licenses.

IPP facilitates NASA's entering into dual-use Technology Development Partnerships. From NASA's perspective, the primary purpose of these partnerships is to provide needed technology and capabilities for NASA's Mission Directorates, Programs, and Projects at less cost through investments and partnerships with private and other external entities. At the same time, these partnerships enable industrial entities to jointly develop commercially applicable technologies at less cost to them. In addition, industry can take advantage of the Agency's unique capabilities and facilities through partnering. The technology spectrum of interest to NASA is so broad that it is difficult to imagine a key industrial sector that could not benefit from partnering with NASA. In FY 2007, IPP facilitated NASA's entering into over 200 such partnerships with private and other external entities.

Similarly, IPP's Investment Seed Fund is designed to enhance NASA's ability to meet mission technology goals by providing seed funding to address barriers and initiate cost-shared, joint technology development partnerships. Seed Fund projects encourage, to the maximum extent possible, leveraging of funding, resources, and expertise from non-NASA partners, NASA Programs and Projects, and NASA Field Centers. Over the life of IPP's Investment Seed Fund, which spans FY 2006–2007, IPP's $15.9 million investment has generated 67 partnerships and resulted in $26.3 million in private capital investment contributed by industrial partners and $20.0 million in contributions from NASA's other programs and projects for a total of $62.2 million for the advancement of Agency critical technologies also having significant commercial applicability.

IPP's SBIR/STTR program provides the small business sector with the opportunity to provide mission use technology for NASA. At the same time, historically about 30 percent of NASA's phase II SBIR/STTR technologies have been commercially applied in key sectors such as aviation, agriculture, automotive manufacturing, advanced materials, communications, electronics, environment protection, sensors, robotics, medicine, manufacturing, heating/air conditioning, optical instrumentation, computing, and software development.

Centennial Challenges is IPP's program of prize contests to stimulate innovation and competition in NASA mission areas. By making awards based on actual achievements, instead of proposals, Centennial Challenges seeks novel technological solutions to NASA's mission challenges from non-traditional sources of innovation

in academia, industry, and the public. As a byproduct, Centennial Challenges is sparking inventive genius and real technology advances created by individuals, academia, and corporations of all sizes, thus providing the basis for future commercial applications and related private capital investment.

NASA recently made a selection in a competitive procurement to provide commercial parabolic aircraft flight services to simulate multiple gravity environments. IPP will utilize this contract to initiate a new activity—Facilitated Access to the Space environment for Technology development and training (FAST). FAST will provide partnership opportunities involving technology development that relies on limited exposure to the microgravity environment. FAST has the dual objectives of demonstrating the purchase of commercial services from the emerging commercial space sector, and advancing maturity of dual-use technologies through use of those services.

Regarding advancements in IPP program implementation efficiencies, IPP is in the process of improving its website and its publications, *Spinoff Magazine, TechBriefs Magazine, Innovation Magazine,* for the purposes of generating increased interest in, and making licensing, partnership development, as well as other opportunities available to a broad range of entities, nationwide. Also, IPP is improving its information technology capabilities that are expected to increase new technology reporting compliance and improve partnership development management.

Accordingly, the IPP program, through its various program elements, therefore provides the opportunity for a broad spectrum of industry, large and small companies alike, to contribute to NASA's missions and simultaneously enhance their own competitive positions in international markets. IPP also challenges the ingenuity of grass roots citizens, inviting entrepreneurs, inventors, and students alike to create innovative technology and thereby contribute to NASA's missions, as well as to help build the foundation for the Nation's future economic prosperity.

Questions submitted by Representative Ralph M. Hall

Science Research to Operational Capability

Q1. The National Research Council has reported several times on the difficulties of the transition of research assets developed by NASA to operational assets managed by NOAA. In particular, one criticism is that while there have been transitions that have been successful; the transition of assets is, by and large, an ad hoc process.

Q1a. Has there been any progress on the development of some type of standardized procedure or memorandum of understanding between NASA and NOAA that would provide guidance for future transitions of assets?

A1a. Substantial progress has been made by NASA and NOAA to ensure maximum coordination in the design, operation, and transition of missions, where appropriate, and to prepare transition plans for the existing and future Earth observing systems found to have potential operational capabilities. Specific examples are outlined below.

In December 2005, the NASA Associate Administrator for the Science Mission Directorate (SMD) and the Department of Commerce (DOC) Deputy Under Secretary for Oceans and Atmosphere approved the Interagency Agreement on Terms of Reference for the NASA Earth Science—NOAA Joint Working Group (JWG) on Research and Operations. The Director, NASA Earth Science Division, and the Assistant Administrator, NOAA Satellite and Information Services, oversee the JWG. The JWG Co-Chairs are the Associate Director for Research, NASA Earth Science Division, and the Director, Climate Program Office, NOAA Office of Oceanic and Atmospheric Research. In October 2006, the Director, NASA Earth Science Division, and the Assistant Administrator, NOAA Satellite and Information Services, established a NASA–NOAA Roundtable that meets approximately quarterly for oversight of JWG functions.

In April 2006, the JWG convened a NASA–NOAA Workshop on Research and Operations Transition Opportunities on five themes: (1) observing capability transition; (2) mission extension; (3) Earth system data records; (4) accelerating the operational use of research data; and (5) tools and standards. Results of the workshop were outlined in the annual report submitted to Congress in July 2008 regarding coordination of Earth science programs for NASA and NOAA as required by Section 306 of the *NASA Authorization Act of 2005* (P.L. 109–155). The next update to this annual report will be submitted to the Committee in the coming weeks.

Since the June 2006 Nunn-McCurdy certification of the National Polar-orbiting Operational Environmental Satellite System (NPOESS), the JWG supported the

NASA and NOAA joint effort to mitigate the loss of climate instruments. In January 2007, NASA and NOAA jointly transmitted "Impacts of NPOESS Nunn-McCurdy Certification on Joint NASA–NOAA Climate Goals") to the White House Office of Science and Technology Policy (OSTP). The four highest-ranked measurement capabilities listed in the report were total solar irradiance, Earth radiation balance, ocean surface topography, and vertical profiles of ozone.

In April 2007, NASA and NOAA agreed to equally share the cost to incorporate the Ozone Mapping and Profile Suite Limb instrument on the NPOESS Preparatory Project (NPP) set to launch in June 2010. In January 2008, NASA and NOAA agreed to modify the Clouds and the Earth's Radiant Energy System (CERES) instrument, which was intended for launch on the first NPOESS spacecraft now delayed to January 2013. The CERES instrument will be launched on NPP to provide continuity with CERES data recorded on NASA's Aqua and Terra satellites. In 2008, NASA and NOAA will jointly develop a plan to fly a Total Solar Irradiance (TSI) instrument on a platform-of-opportunity.

In January 2008, the NASA–NOAA Roundtable established a research-to-operations joint working team (R2OJWT) to develop processes to transition the NASA satellite nadir altimetry research measurement capability to NOAA for operational service. As noted above, the satellite nadir altimetry measurement capability had the third highest priority in the NASA–NOAA report to OSTP on mitigating the impact of the Nunn-McCurdy certified NPOESS.

The R2OJWT was instructed to consider the guidance provided in the report "Satellite Observations of the Earth's Environment: Accelerating the Transition of Research to Operations" published in 2003 by the National Research Council (NRC) Committee on NASA–NOAA Transition from Research to Operations, known as the CONNTRO Report. The Roundtable will provide oversight guidance of the R2OJWT's activities.

Valuable lessons learned by the R2OJWT will guide the establishment of an Interagency Transition Office (ITO), which will be jointly staffed by NASA and NOAA. While funds are not now available to fully implement all CONNTRO Report recommendations, NASA and NOAA intend to formally implement an ITO activity.

Q1b. If not, do you plan on reaching out to NOAA to develop such guidance?

A1b. As outlined above, NASA and NOAA have an ongoing process to achieve the transition of NASA satellite measurement capabilities designed for research purposes to NOAA satellite measurement capabilities for operational utilization of the data. NASA and NOAA have chosen the satellite nadir altimetry capability to be the first satellite measurement capability for transition from NASA to NOAA.

International Participation Limited by ITAR

Q2. With respect to collaborating with our international partners on current and future missions, how severely does ITAR impede NASA's ability to work with foreign scientists, engineers, and space agencies? Based on your experience working under the ITAR regime, do you have any recommended changes that maintain the spirit of ITAR but that provides meaningful relief? If so, what are they?

A2. Although the Department of State has recently taken steps to address certain ITAR-related impediments, including actions in furtherance of the President's export control reform directives of January 22, 2008, some ITAR requirements continue to impact NASA's ability to work with its international partners. The most common ITAR concerns for NASA and its contractors relate to export license process requirements, license restrictions regarding anomaly resolution, and restrictions affecting foreign governmental employees with dual-nationalities. These problems result in schedule delays, cost overruns, the need for workarounds, and the inability of contractors to perform necessary work with NASA's international partners in the absence of proper export control authorizations; they may also impede the ability of NASA and its contractors to expeditiously take action to assure operations safety and mission success. Accordingly, NASA has been working closely with the Department of State since 2001 on proposals to obtain its own export authority and other improvements to address these challenges. The centerpiece of this effort for NASA has been the pursuit of an appropriately-circumscribed ITAR exemption, modeled on the Arms Export Control Act's Foreign Military Sales exemption utilized by the Department of Defense and its contractors. This approach is consistent with the recommendations of both the Congressionally-chartered International Space Station (ISS) Independent Safety Task Force (IISTF) report of February 21, 2007, which found that ITAR restrictions "are a threat to the safe and successful integration and operations of the [International Space] Station" and recommended that the Department of State "grant immediate relief in the form of an [ITAR] exemption," and the

May 18, 2007, NASA Advisory Council endorsement of an exemption "to facilitate NASA's critical tasks in implementing the [U.S. Space Exploration Policy] and other NASA programs." Recently, the State Department advised NASA to seek legislative authority as a prerequisite to the Department's promulgation of an exemption to facilitate the implementation of NASA's programs, including the U.S. Space Exploration Policy. NASA will continue to work closely with the State Department and other agencies of the Government on this recommendation and other appropriate avenues to address NASA's ITAR-related concerns and those of its contractors.

Earth Science Decadal Survey

Q3. Last year, the National Research Council released its report, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond" in which they identified 17 critical missions that should be undertaken in the next decade. Based on the usefulness of this information to the operational and scientific communities studying climate change, does NASA have a plan to work with NOAA regarding the prioritization, funding and management of these missions? If not, why not?

A3. Yes. The National Research Council's Decadal Survey (NRC, 2007), the first such survey for NASA Earth Science and NOAA, recommended fourteen and two satellite missions, respectively, to launch during 2010–2020. One additional mission was recommended for NASA and NOAA to jointly implement for launch in 2010–2013. The Decadal Survey mission priorities are the principal determinant of the priority of NASA's Earth Science satellite missions beyond those currently in development.

At NASA's invitation, NOAA participated in NASA-sponsored community workshops in June and July 2007 to initiate scientific discussions of, and begin defining data products from, the four near-term missions assigned to NASA by the Decadal Survey. A report of each workshop is available at *http://nasascience.nasa.gov/earth-science.* One of these four (CLARREO) is the mission the NRC recommended for joint NASA/NOAA implementation. In addition, NOAA is also exploring, with NASA participation, concepts for a satellite ocean vector winds mission that can meet NOAA mission requirements, which the Decadal Survey named the "eXtended Ocean Vector Winds Mission" (XOVWM).

Each Agency will prioritize, fund, and manage the missions and mission elements for which it is responsible. For the joint NASA/NOAA mission recommended by the NRC (CLARREO), the NRC recommendation contained a first-order distribution of responsibilities for the Agencies—it was recommended that NASA should fund and manage the spectrally resolved measurements, while it was recommended that NOAA should fund and manage the broadband measurements. On a reimbursable basis, NASA has been supporting NOAA on studies of the XOVWM mission.

A more complete description of NASA/NOAA collaboration in Earth Science, including activities related to Decadal Survey and other NRC recommendations, is reported to Congress annually in a report required by Section 306 of the *NASA Authorization Act of 2005* (P.L. 109–155).

National Polar-orbiting Operational Environmental Satellite (NPOESS)

Q4a. Last month, the Executive Committee (EXCOM) for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) met for its regular quarterly meeting. As I understanding it, during that January EXCOM, there was a decision to keep the VIIRS instrument as part of the NPP satellite (the first NPOESS satellite), which has caused an eight-month slip in the timeline for launch. How did this eight-month slip occur?

A4a. The delay in the launch readiness date of the NPP satellite is driven entirely by delays in the delivery of the Visible Infrared Imager Radiometer Suite (VIIRS) instrument.

Q4b. What is the EXCOM doing to ensure that further slips will not delay the satellite any longer?

A4b. VIIRS has been built and is undergoing a series of tests to qualify for the NPP mission. To enable timely actions to keep NPP on schedule, the EXCOM meets approximately quarterly with high-level management of the manufacturers preparing VIIRS for deployment on NPP. In addition, the EXCOM meets at quarterly intervals with the NPOESS Program Executive Officer (PEO), who has oversight of delivery of VIIRS on NPP. The EXCOM receives monthly status reports from the PEO. In January, the EXCOM directed the PEO to meet biweekly with the leadership team

of the VIIRS contractor to ensure that the Government concerns are being addressed. The PEO delivers a report on the outcome of those meetings to the EXCOM.

Q4c. What is the effect to the program if further delays are experienced?

A4c. The additional cost to NASA associated with an eight-month delay from September 30, 2009, to June 2, 2010 is a total of $42.2M. The additional amount for an eight-month delay covers the following costs:

- A technical support workforce and infrastructure are required to maintain already-built instruments, equipment, and facilities to be available at launch. The major NASA-provided items are the spacecraft; the Advanced Technology Microwave Sounder (ATMS) instrument; the Science Data System (SDS) Product Evaluation and Analysis Tool Elements (PEATES) for the atmosphere, ocean, land, ozone, and sounder; the launch vehicle; and the management for the NPP mission. The ATMS has already been integrated into the spacecraft and the PEATES are ready to perform their tasks. The subtotal for these activities is $22 million.
- In 2008 and 2009, NASA will modify the Clouds and the Earth's Radiant Energy System (CERES) Flight Model (FM) 5 instrument and the spacecraft, and integrate CERES with the NPP spacecraft and ground data system. These minor modifications can be undertaken without significantly impacting technical risk or schedule for NPP. The cost for activities related to the CERES instrument is $17.7M, primarily for data production and product generation. The purpose of placing the CERES instrument on NPP is explained below. In January 2008, the EXCOM agreed with the NASA decision to add the only remaining CERES instrument to NPP. The CERES FM5 instrument had been scheduled to fly on the first NPOESS spacecraft to provide continuity with CERES data recorded on NASA's Aqua and Terra satellites, which will be operating beyond their design lifetimes at the time of the planned launch of NPP. Programmatic slips have delayed the first NPOESS launch to January 2013. A gap of CERES top-of-atmosphere radiation budget data in a changing climate system would require doubling the length of the data set to quantify the impact of clouds on the global integrated climate system.
- The eight-month delay will increase a variety of pre-operational costs totaling $2.5M.

Should a delay occur after the scheduled launch date of June 2, 2010, the cost to NASA to maintain instruments, infrastructure and activities in readiness for an NPP launch is $4.1M per month. This monthly amount covers costs for the spacecraft, ATMS instrument, CERES instrument, PEATES science data system, launch vehicle, and a variety of pre-operational activities. A delay penalty will increase launch vehicle costs from $0.6M per month before June 2, 2010, to $1.3M per month after June 2, 2010.

Restrictions on Purchasing Russian Launch Services

Q5. Given the possibility that COTS (Commercial Orbital Transportation System) could fail to produce a viable cargo delivery capability and that the Iran, North Korea and Syria Non-Proliferation Act (INKSNA) bars NASA from purchasing launch services from Russia after 2011, what is NASA's backup plan to service and maintain ISS after 2011 if INKSNA is amended?

A5. NASA has always envisioned a mixed fleet strategy. If neither COTS nor non-U.S. vehicles are available to meet logistics needs for operating and maintaining the ISS, NASA would have no alternative but to actively and aggressively manage spacecraft systems degradation in a manner that minimizes the probabilities of loss of systems and loss of vehicle until such time as the needed transportation services become available. It should be noted that the European ATV has recently successfully docked to the ISS. The ISS partnership took measures during the period when the Shuttle was grounded following the *Columbia* accident to minimize logistics needs, so we have experience in managing with transportation constraints.

Q6. NASA's FY 2009 budget request includes $2.6B to purchase ISS transportation services through 2013. In order for NASA to purchase Soyuz flights after 2011, Congress must amend the INKSNA. Assuming the Administration plans to seek an amendment for INKSNA, when should Congress expect to receive the request?

A6. On April 14, 2008, NASA submitted to the Congress a proposed amendment to extend the exception for payments to Russia for Soyuz crew transportation and rescue services until the Orion Crew Exploration Vehicle reaches Full Operational Capability or a U.S. commercial provider of crew transportation and rescue services demonstrates the capability to meet ISS mission requirements. It also extends through the life of the ISS the exception for payments for Russian-unique equipment and capabilities, such as sustaining engineering and spares (for example, acquiring Russian equipment for use in training in the U.S., and hardware, such as spares, to outfit the Russian-built, but U.S.-owned, Zarya module). NASA looks forward to working with the Congress on enactment of this legislation that is crucial for the long-term operation of the ISS.

Rational for Ares Development

Q7. Using material from the Exploration Systems Architecture Study, or other studies if appropriate, please detail for the record why the requirements of a lunar-capable Orion spacecraft dictate the development of Ares, and why Orion is incapable of using other launch vehicles. In the event that a future loss of the Ares launch vehicle causes a stand-down, is there any contingency scenario that would permit Orion to be launched to the ISS on any currently existing launch vehicles either international or domestic?

A7. NASA evaluated many launch vehicle options that could be utilized for human space exploration missions. Over two years ago, the Agency conducted a very thorough study of architectural alternatives to meet our needs for International Space Station resupply and return to the Moon during the Exploration Systems Architecture Study (ESAS). The principal factors considered during ESAS were the desired lift capacity, the comparative reliability, and the development and life cycle costs of different approaches. A primary driver for developing the Ares I launch vehicle is that NASA required a human-rated launch vehicle to transport the crew into low-Earth orbit. The Ares I is comprised of components used in a human-rated vehicle (Space Shuttle), because the identified *safety projections for the selected Shuttle-derived solution are approximately two times that of the Evolved Expendable Launch Vehicle (EELV) based Crew Launch Vehicle (CLV) solutions.*

Among these approaches, NASA considered existing vehicles, such as the EELV fleet, to meet crew and cargo transportation needs. The additional information following outlines in depth why NASA decided to move forward with the Ares launch vehicles after careful consideration and study of other launch alternatives.

NASA does not have a contingency option to fly the Orion Crew Exploration Vehicle on any other vehicle, regardless of whether it is a domestic commercial, international commercial or foreign government vehicle. The Orion was built to meet specifications of the Ares Crew Launch Vehicle. Modifying Orion to fit other EELVs would be beyond NASA's budget and require significant changes to the EELVs.

Additional information

February 2008

Why NASA Chose to Utilize a Shuttle-Derived Crew Launch Vehicle Instead of Human Rating an Evolved Expendable Launch Vehicle

NASA evaluated many launch vehicle options that could be utilized for human space exploration missions. The principal factors considered were the desired lift capacity, the comparative reliability, and the development and life cycle costs of different approaches. Among these approaches, NASA considered existing vehicles, such as the EELV fleet, to meet crew and cargo transportation needs. This white paper outlines why NASA decided to move forward with the Ares launch vehicles after careful consideration and study of other launch alternatives.

Developing NASA's Exploration Architecture

NASA is developing the Exploration architecture to safely and affordably transport humans and cargo beyond low Earth orbit (LEO). This multi-purpose architecture is not simply a "ferry to the International Space Station (ISS)," or a "Shuttle replacement." Instead, by utilizing tested human space elements, it includes the Heavy Lift Launch Vehicle (HLLV) to deliver up to 70–75 metric ton (mT) of cargo to Trans Lunar Injection (compared to the Apollo/Saturn capability of approximately 47 mT).

NASA studied hundreds of commercial, Government and concept launch vehicle and architecture systems prior to 2005, culminating in the release of the Exploration Systems Architecture Study (ESAS). NASA studied Space Shuttle-derived, EELV-derived as well as "clean sheet" launch vehicle architectures in cooperation with the U.S. launch industry, and concluded that the Ares I and V system architecture provided the optimal solution for both LEO and beyond LEO applications. Figures of Merit (FOMs) used during the studies—cost, reliability, human safety, programmatic risk, mission performance and schedule—were applied to drive out the best alternative in the analysis. Additional considerations included legal requirements from the *NASA Authorization Act of 2005* (P.L. 109–155), workforce skills and industrial capabilities. After a thorough analysis of the entire Exploration architecture requirements, EELV solutions were ultimately determined to be less safe, less reliable, and more costly than the Shuttle-derived solutions in development.

The ESAS concluded that NASA should adopt and pursue a Shuttle-derived architecture as the next-generation launch system for exploration missions due to their significant advantages, particularly with respect to safety, reliability, and cost. The extensive flight and test databases of currently flying hardware/software give a very strong technical and safety foundation with clearly defined and understood elements to anchor next-generation vehicles and minimize development costs and risks to flight crew. In addition, NASA's approach allows the Nation to leverage significant existing ground infrastructure investments (Kennedy Space Center (KSC); Michoud Assembly Facility (MAF), etc.) and personnel with significant human space flight experience. Overall, NASA's Shuttle-derived approach was found to be the most affordable, safe, and reliable approach, both by leveraging proven human rated vehicle and infrastructure elements and by using common elements across the architecture. While NASA continues to conduct trade studies aimed at refining the Ares V architecture for minimum development risks and operational costs, the Agency is committed to the fundamental Ares I/V approach established over two years ago.

The next section of this white paper explores some of the specific reasons why NASA chose the Ares architecture for future space flight missions, both manned and unmanned.

The Ares versus the EELV

Vehicle Performance: The EELV crew transport options examined were those of the Delta IV and Atlas V families. The study focused on the heavy lift versions of both Delta (currently flying) and Atlas families (drawings only), and confirmed that none of the medium versions of either vehicle had the capability to accommodate the Orion Crew Exploration Vehicle lift requirements. The Medium class EELVs, with no additional solid boosters, significantly under performed by approximately 40–60 percent. The option of using small, strap-on solid boosters was eliminated for safety reasons in the Orbital Spaceplane Safety Study conducted in 2004. Both EELV-heavy vehicles were assessed to require significant modification for human-rating, particularly in the areas of avionics, telemetry, structures, and engine selection. Additionally, both the Atlas and Delta Heavy classes required development of new upper stages to achieve the lift performance required to launch Orion. Ares I is designed to launch the 23.3 mT Orion vehicle, which consists of the crew and service modules, into LEO. The Ares can also launch a 20.3 mT Orion to the inclination of the ISS.

The ESAS assessment showed that lunar missions requiring more than three launches dramatically reduced the probability of mission success. Therefore, NASA issued an architecture goal to minimize complex on-orbit assembly, and also placed a limit to no more than three launches for a mission. For lunar missions, this equates to a launch vehicle design with a lift capability near 100 mT or greater to LEO. Early in the trade study process, NASA identified the current EELV fleet, if used for lunar cargo missions, would require more than seven launches per lunar mission. This very high number of flights per mission is unacceptable from a mission success probability standpoint and did not meet the NASA goal of three launches maximum.

While elements of current EELVs can be utilized to develop a 100 mT LEO equivalent launch vehicle (boosters, engines, etc.), the lack of acceptable EELV boost stage performance (compared to Shuttle-derived hardware) drives the need for an additional Liquid Oxygen (LOX)/Liquid Hydrogen (LH2) stage to reach orbit. The EELV-derived solutions required two upper stages as well as additional strap on core boosters to provide the necessary lift capability to minimize launches for on-orbit assembly. These characteristics were deemed to decrease mission safety and reliability while increasing costs to unacceptable levels based on NASA requirements. NASA did not pursue "clean sheet of paper" designs because it was deemed too risky and expensive.

Crew Safety/Reliability: The current EELVs were designed to carry unmanned payloads. Modifying the EELV design to meet the Human-Rating Requirements would require changes in areas such as flight termination system changes to add a time delay for an abort scenario and in-flight crew control/abort capabilities. The use of EELVs for crew transportation would also require NASA to invest significant funds into pad modifications required for crew access/emergency egress that currently does not exist at the EELV launch site. Based on ESAS assessments, the Shuttle-derived launch vehicle was highest-rated in terms of crew safety by about a factor of two over other options (Loss of Crew approximately 1/2000). This confidence for crew safety is driven by the extensive history of the Shuttle system, which far surpasses the experience base for any other existing system. To add to the reliability of the system, the Ares I hardware is recovered and inspected for any system anomalies. In addition, Shuttle propulsion systems are already "human-rated" which mitigates one of the highest programmatic risks for a launch vehicle. Leveraging systems that are already human-rated reduces the uncertainties and risks associated with human-rating the new CLV. In addition, the current EELVs have a booster structural Factor of Safety (SF) of =1.25, where NASA requires that all structures have a 1.4 Factor of Safety (NASA Standard NASA–STD–5001). If the Agency were to accept the reduced SF of the EELVs, a large engineering and development effort would be required to validate structural integrity relative to NASA Standard and would likely eventually lead to some structural redesign of select systems. In addition, main propulsion systems would require modification, for example, the RL–10 upper stage engine would also require human-rating in areas such as: Redundancy upgrades; increased subsystem robustness; fault detection; isolation and recovery; engine redlines; safe in-flight shutdown mode; and, any design changes from structural assessments. For Atlas V, RD–180 American co-production and human-rating would be required adding greater challenges. From a human-rating perspective, the RD–180 will require additional redundancy and increased robustness in select systems. Finally, for Delta IV, several modifications would be required to human-rate the RS–68 including extensive health monitoring, increased robustness of subsystems, and elimination of the fuel-rich environment at liftoff which would pose a crew hazard.

Life Cycle Costs: The Ares I and Ares V combination for lunar missions provides significantly lower non-recurring cost than that of the current EELV launch vehicle families. The Shuttle-derived launch vehicle combination allows for a "1.5 launch" solution whereas the EELV architectures required two HLLV launches with more expensive hardware costs. It was determined that the total EELV-derived CLV plus EELV-derived Cargo Launch Vehicle (CaLV) Design, Development, Test, and Evaluation (DDTE) costs are approximately 25 percent higher for EELV-derived versus selected Shuttle-derived architecture.

The launch cost for human-rated, EELV-derived systems is significantly higher than the current cost of a medium-class EELV. This launch cost also does not include the non-recurring development investment required to meet the Orion's lift requirements and human-rate these systems, which has been estimated to cost in the several billions of dollars. In order for the unmanned payload customers to not incur the unnecessary additional costs for human-rated systems on the EELV, the EELV providers would likely need a unique human-rated variant which would increase the costs.

NASA continued to refine its launch recommendations post-ESAS. In early 2006, NASA modified the architecture from a four-segment Reusable SRB (RSRB)/single Space Shuttle Main Engine (SSME) upper stage CLV, and a five-segment RSRB/Expendable SSME Core/J–2X Earth Departure System (EDS) CaLV to a five-segment RSRB/single J–2X upper stage CLV, and five-segment RSRB/RS–68 Core/J–2X EDS. After careful analysis, NASA elected to forgo the modification of the SSME for altitude-start and proceed directly to development a common J–2X engine for both the Ares I upper stage and the Ares V Earth departure stage, which sends the Orion crew capsule/lunar lander combination to the Moon. This new approach eliminates a top ESAS-identified risk—SSME altitude start—and addresses another risk—J–2X development—sooner thereby lowering overall Exploration risks and costs. In addition, the inordinate expense of using five SSMEs with each cargo launch made the selection the relatively simple (and much less costly), utilizing the expendable RS–68 engine with the added advantage of using a common engine to meet both Department of Defense and NASA needs. With this approach, engine development for the Ares I provides a significant and direct "down payment" on the Ares V test and development plan. Selecting common hardware not only maximizes non-recurring investments and reduces overall life cycle cost; it also gets NASA closer to enabling a lunar transportation system. Concentrating efforts on two major propulsion devel-

opments rather than on five, as was originally proposed, will reduce development costs by hundreds of millions of dollars and save billions in operations costs. These combined changes represented a projected savings of over $5 billion in life cycle costs over the initial ESAS recommendations.

Infrastructure and Capability Retention: While NASA will continue to use existing U.S. expendable launch vehicles for the robotic exploration missions (five to eight launches per year), the Ares V system leverages heritage human-rated systems such as the Shuttle Solid Rocket Motor; the Solid Rocket Booster, as well as heritage infrastructure, including the MAF in Louisiana; and the Vertical Assembly Building and crawler and launch complex 39 at KSC in Florida. To sustain the manufacturing infrastructure capability required for the Ares V between Shuttle retirement and the first human lunar launch, NASA's Exploration architecture (Shuttle-derived Ares I) ensured America's industrial base for production of large solid rocket systems, high-performance liquid engine systems, large lightweight stages, large-scale launch processing infrastructure, and the current production level of solid propellant fuels is available to support the Ares V. If NASA selected the EELV-based CLV options, this would have required a significant amount of "keep alive" costs to maintain the industry and Center infrastructure and skills assets for eventual use on Ares V development.

External Reviews: Several external reviews have been conducted with regard to NASA's launch vehicle selection, with all reviews to date supporting the direction of the Agency. NASA's conclusions regarding the Space Shuttle-derived Ares I and V vehicles have received agreement by the Department of Defense (DOD) and results were validated by Congressional Budget Office (CBO) and Government Accountability Office (GAO) reports. In 2005, the DOD reviewed NASA's analysis and concurred with NASA's approach. A joint recommendation was formally submitted in a memorandum to the Director of the Office of Science and Technology Policy, Dr. John Marburger, in August 2005.

In October 2006, CBO concluded a study on the NASA's selection of the Ares I and Ares V launch vehicles ("Alternatives for Future U.S. Space Launch Capabilities Report"). The CBO report contrasted CBO's analysis with the recent NASA ESAS report and resulting implementation approach and identified a number of observations, highlighting four main points:

1. Fewer launches per exploration mission increases overall mission reliability;
2. NASA's Shuttle-derived launch vehicle approach is the most economical option when minimizing the number of launches;
3. Since CBO cost results are consistent with NASA's ESAS conclusions, and since NASA also based its launch decisions on safety and reliability (not assessed by CBO), NASA's selection of a Shuttle-derived launch vehicle is further validated by the CBO study; and
4. The CBO estimates for the NASA-selected launch vehicles are within NASA budget projections."

And the most recent report from the GAO in November 2007 ("Agency Has Taken Steps toward Making Sound Investment Decisions for Ares I but Still Faces Challenging Knowledge Gaps Report") noted that "NASA has taken steps toward making sound investment decisions for Ares I." The GAO report also noted that:

> "Furthermore, NASA's decision to include the J–2X engine and five-segment booster in the Ares I design in order to reduce long-term operations and support cost is in line with the practices of leading commercial developers that give long-term savings priority over short-term gains. The Ares I project was also proactive in ensuring that the ongoing project was in compliance with NASA's new directives, which include elements of a knowledge-based approach. NASA's new acquisition directives require a series of key reviews and decision points between each life cycle phase of the Ares I project that serve as gates through which the project must pass before moving forward . . . We found that the Ares I project had implemented the use of key decision points and adopted the recommended entrance and exit criteria for the December 2006 Systems Requirements Review and the upcoming October 2007 Systems Definition Review."

Summary

NASA is designing transportation architecture, not just a point solution for access to LEO. In deciding on this architecture, NASA considered principal factors such as performance, reliability and development and life cycle costs when comparing alternatives. NASA also took into consideration the growth path to heavy lift capability

which results from the choice of a particular launch vehicle family. To grow significantly beyond today's EELV family for lunar missions requires essentially a "clean sheet of paper" design, whereas the Ares V design makes extensive use of existing elements, or straightforward modifications of existing elements, which are also common to Ares I. The Shuttle-derived launch vehicle architecture selected by NASA meets all of the goals and objectives to achieve the exploration mission, while also:

- Providing the best possibility of meeting stakeholder and customer requirements, including legal mandates, within the funding available and timeframe desired; Providing the safest, most reliable and cost effective launch vehicle for NASA missions;
- Maximizing leverage of existing, human-rated systems and infrastructure;
- Leveraging collaboration between the retiring Shuttle Program and emerging Constellation projects by sharing lessons learned and transitioning valuable resources, ranging from a specialized workforce to a unique launch infrastructure;
- Creating the most straightforward growth path to later Exploration launch needs; and
- Ensuring the industrial base for production of large solid rocket systems, high performance liquid engine systems, large lightweight stages and critical, large scale launch processing infrastructure.

Questions submitted by Representative Tom Feeney

Shuttle Retirement

Q1. As NASA continues to shut down vital Shuttle suppliers and close out contracts, when will we reach "the point of no return," making it prohibitively expensive to purchase consumables and spares for future flights? How does NASA intend to ensure a sufficient number of spares remain available to support Shuttle operations through 2010 and just as importantly, that the workforce and industrial base will remain intact for the transition to Constellation?

A1. NASA already has contract vehicles in place to ensure that the current manifest of Space Shuttle missions is fully supported with all required consumables and spares, and the Agency has begun to modify contracts to reflect the final orders of Space Shuttle Program hardware. Recent examples of this include modifications to the Reusable Solid Rocket Motor (RSRM) contract with ATK and the Super Lightweight External Tank contract with Lockheed Martin.

As detailed in the report submitted to the Committee in April 2008 regarding NASA's initial Workforce Transition Strategy, the Agency indicated its greatest management challenge is managing our extremely talented, experienced, and geographically dispersed workforce as we transition from operating the Space Shuttle to utilizing the International Space Station and expanding our reach to the Moon, Mars, and beyond. The joint effort between the Space Operations and Exploration Systems Mission Directorates includes the utilization and disposition of resources, including real and personal property, personnel, and processes, to leverage existing Shuttle and Space Station assets for future Exploration activities, including the Orion Ares I, and Ares V projects. Formalized Transition Boards are working to successfully achieve this outcome, and, to date, NASA has met all of its milestones and disposition targets. As required by the FY 2008 Consolidated Appropriations Act (P.L. 110-161), NASA will update the Agency's Workforce Transition Strategy report every six months to keep the Congress informed of progress on transition activities.

Shuttle Closeout Costs

Q2. The Space Shuttle budget does not contain any funds for program closeout activities after 2010, and represents an as-yet-to-be-determined threat to the Constellation program, currently estimated at about $1.2B. Are there sufficient reserves in the Constellation program to handle this? Will these costs generate shortfalls that could affect NASA's ability to meet the proposed operational date of March 2015?

A2. The FY 2010 budget formulation will produce the most detailed and accurate Transition and Retirement estimate to date, which is expected to be less than previous estimates given the increased maturity of requirements, more clearly defined process guidelines, and better overall understanding of the type and scope of work to be accomplished. As part of NASA's FY 2010 budget formulation process, the

Constellation program will evaluate estimated costs and determine the best strategy for budget adoption. Although currently carried as a threat, the Constellation program is notionally prepared to accept a threshold cost of $450M that will come from program reserves. However, the goal is to keep these costs to an absolute minimum. Any costs greater than this amount may have an adverse impact on the Orion Crew Exploration Vehicle Initial Operational Capability of March 2015.

Shuttle Extension

Q3. If the Shuttle schedule slips and it becomes necessary or desirable to fly the last two contingency Shuttle missions after 2010, can NASA estimate the cost of extending the Shuttle program on a monthly or quarterly basis? Is there a 'point-of-no-return' after which is would be too late to attempt, and how would any plan to extend the Shuttle program beyond 2010 affect the liens on the Constellation program?

A3. NASA cannot continue flying the Space Shuttle past FY 2010 while maintaining a balanced overall program of science, exploration, and aeronautics and aggressively developing the next-generation exploration systems under the Constellation program. There are two main reasons for this. First, maintaining even a minimal capability to launch two Shuttle flights per year after FY 2010 would require nearly the same infrastructure and vendor capabilities we have today, at a cost of approximately $2.7–$4.0B per year. Unless an equal amount was added to the NASA budget to offset these costs, the funds would have to come at the expense of higher priority activities in science, exploration, and aeronautics. Second, the Constellation architecture is designed to take advantage of Space Shuttle infrastructure, production capabilities, and workforce once they are no longer needed for flying the Shuttle. If the Shuttle were kept flying past 2010, these capabilities could not be released for Constellation's modification and use. As a result, keeping Shuttle flying past 2010 would only compound the problem of getting Constellation into service and exacerbate the gap in U.S. human space flight capabilities. It will also be extremely difficult to keep the Shuttle workforce engaged as Shuttle fly out is extended. A very dedicated workforce is needed to safely operate this complex machine. Ending on a planned date, known well in advance, is much easier for the workforce and planning than a floating end date.

Q4. If Congress directed (and funded) NASA to manifest another mission to fly the AMS, does NASA have the necessary parts and equipment available? What would be required to put the mission together and what are the constraints? What is the cost estimate?

A4. NASA is planning to have enough hardware on hand to maintain a crew rescue option, also know as Launch-on-Need (LON), through the last planned flight of the manifest, STS–133. In principle, after STS–133 this hardware could be turned around to fly AMS and additional hardware to the ISS. However, there would be considerable, nontrivial costs and technical impacts associated with adding such a mission to the end of the manifest in either FY 2010 or FY 2011. NASA has estimated that doing all the work necessary to add an additional flight to the Space Shuttle manifest in FY 2010 would cost approximately $300–$400M. Maintaining the capability of launching one to two Shuttle flights per year after FY 2010 would cost approximately $2.7–$4.0B per year. The later the decision to add a flight is made, the more costs will be incurred to re-enable needed capabilities that are planned for phase out over the next two years.

This new mission could be assembled using the hardware now being built to support a contingency crew rescue flight for the last mission on the current manifest, STS–133. The biggest piece of flight hardware production, and the pacing item for flying an additional flight, would be completing production of the external tank. If NASA were directed by Congress to fly an additional Space Shuttle mission to accommodate AMS, we would probably use the external tank (ET–138) that is now assigned to the STS–133 crew rescue mission. In that case, NASA would be required to complete the partially-built ET–139 (which right now is only being built up to the sub-assembly level to maintain critical workforce skills) to serve as the crew rescue tank for the new AMS mission.

If AMS could be flown before the end of FY 2010, most of the contracts, sub-contracts, vendors, and workforce would still be in place to safely fly the mission. However, much work would need to be done to enable an additional flight in FY 2010, and it remains to be seen whether a flight could be safely added before the end of that fiscal year. This rough estimate of $300–$400M includes anticipated costs of procuring flight hardware, maintaining launch and landing personnel at Kennedy Space Center, and retaining other critical sustaining engineering and processing

personnel through the end of FY 2010. NASA's $2.7–$4.0B estimate to maintain the capability of flying past FY 2010 is based on the level of effort required to maintain the contracts, workforce, and infrastructure needed to support safely flying the Space Shuttle system at a sustained but reduced flight rate. In addition, delaying the retirement of the Space Shuttle and the subsequent refocusing of Shuttle workforce, facilities, and resources on the Constellation Program would negatively impact the development and schedules of the Orion Crew Exploration Vehicle and the Ares family of launchers.

Medium Lift Launchers

Q5. Many of NASA's science missions have been launched on the Boeing Delta II, arguably one of the most reliable launch vehicles ever built.

Q5a. What is the current status of the Delta II system?

A5a. Delta II production has ceased, but it remains an operational program and NASA has missions flying on the launch vehicle into 2011. United Launch Alliance (ULA) has enough parts to build several more vehicles. NASA will consider using those vehicles should missions arise needing that class of vehicle. Some of the major components are out of production, which would need to be re-started to produce vehicles beyond those in inventory.

Q5b. Are there any options in which Delta II production could continue, and if so, will it come at a price that NASA can afford?

A5b. Delta II production could be re-started, but the cost is much too large for NASA to pay for. In addition to the cost of re-starting production, there is also the cost of vehicle infrastructure that needs to be considered. NASA is unable to afford those costs by itself, either. The two-pad configuration at Cape Canaveral Air Force Station (CCAFS), 17A and 17B, will likely be reduced to one pad in 2009 or 2010.

Q5c. Other than the Orbital Sciences latest COTS award for a potential Taurus II, what steps is NASA taking to ensure continued access to an affordable, reliable medium-lift launcher?

A5c. Taurus II is being considered as an option for future medium-lift missions. ATK/Planet Space are considering re-starting the Athena product line to include an Athena III medium-class launch vehicle. SpaceX's Falcon 9 launch vehicle is another possibility, and the development of that vehicle is well underway. NASA has been asked by Orbital and ATK to participate in both companies' engineering development processes. Unfunded Space Act Agreements are being developed currently to support those efforts.

NASA is considering buying future launch services in all classes in blocks—buying a group of services instead of purchasing them one at a time. This is desirable to the extent that it generates efficiencies for production by the manufacturers or is advantageous to the government. Manufacturers are able to buy their hardware in quantity, which reduces costs. Delta II launchers have been purchased in this manner. NASA has had a good experience purchasing services in this manner, and it appears to make sense for the future. Internally, work continues on fine-tuning the manifest between 2011 and 2015 to see what the missions in each class, small, medium and large, are likely to be.

In April, NASA released a Request for Information to gather information on the small- and medium-class mission set from potential launch service providers.

Constellation

Q6. Based on experience to date with the Orion and Ares programs, what do you consider the three highest risks, and what steps are being taken to address them?

A6. A context on "risk" is required to answer this question. The current development projects within Constellation are not the leap forward in technology that previous efforts, such as X–33, were. This increases NASA confidence in them. In addition, the Constellation Program utilizes an active risk management approach, which involves regularly identifying, evaluating, and retiring the risks, which are affecting the program. Although NASA has many challenges, we are on track and making progress in managing these challenges. The greatest challenge NASA faces is flying the Space Shuttle to complete assembly of the ISS prior to retiring the Shuttle in 2010, while also bringing the new U.S. human space flight capabilities on-line soon thereafter. Stable funding for Constellation is needed to assure a timely transition

between Shuttle and the Orion and Ares I as well as proper management of funding reserves.

One of the top Constellation Program technical risks is the development of the Ares I upper stage engine, J2X. Currently, the J2X is one of the critical path items within the Program. In an effort to retire the development risk of the J2X, the Program has decided to add resources to the development to make it more robust. This change incorporates additional testing hardware and tests to increase the confidence of success. This enhancement also includes early activation of the alternate test stand, additional tests, and additional engines for testing.

Another technical risk within the Constellation Program is the Ares Thrust Oscillation induced by the internal configuration of the reusable solid rocket motor. During design analysis, it was observed that there is a possibility that the thrust oscillation could cause unacceptable structural vibration. A "tiger team" was created to further study the potential issue and to develop mitigation strategies. Mitigation options identified to date could include stiffness and dampening design changes to the Ares I first stage, Interstage, LOX and LH2 Tank Barrel and Instrument Unit structures. The problem is actively being worked and on a path to implement a "solution" this summer.

Aeronautics

Q7. Two years ago, when NASA began reshaping the Aeronautics Research Mission Directorate, the Federal Aviation Administration (FAA) expressed concern about its inability to take new—but relatively immature—technologies developed by NASA and transition them to the NextGen program. Have NASA and FAA come to any agreement with respect to transitioning research, especially the level of technical readiness?

A7. NASA Aeronautics, the FAA Air Traffic Organization (ATO), and the JPDO are working collaboratively to establish a process to transfer technologies from fundamental research and development (R&D) into implementation for the NextGen. This process, which ensures research is sufficient and appropriate to enable NextGen, has top-level commitment from Dr. Jaiwon Shin, NASA Associate Administrator for Aeronautics and Ms. Victoria Cox, FAA Vice President for Operations Planning Services, Air Traffic Organization. A coordinating committee that includes both FAA and NASA representatives oversees four initial research transition teams that are organized around the NextGen Concept of Operations framework. This framework connects the FAA's Operational Evolution Partnership elements with the NASA research. The JPDO has an important role in the transfer in that they will inform the Integrated Work Plan with progress. The teams are working to plan near-term R&D transition in areas such as surface management and long-term transition in areas such as dynamic airspace allocation. With regards to an initial collaborative Research Transition Team activity, more than 35 participants from FAA service units, NASA, MITRE/CAASD, and industry attended a workshop in Washington, DC, in February 2008, to focus on integration of NASA and FAA research plans, schedules, roadmaps, and coordinated simulations for near term NextGen Trajectory Management objectives.

Budget Accounts

Q8. Please describe the efforts NASA has underway and planned to implement the new account structure directed by the FY 2008 Appropriations Omnibus legislation.

A8. NASA is undertaking all activities required for implementing a new appropriations account structure as directed. NASA has so far accomplished the following:

- Modified the Agency budget systems to implement the new appropriations account structure;
- established new Treasury accounts to implement the directed change in appropriations account structure;
- developed all required materials for the President's budget systems and documentation that enabled submission of the President's FY 2009 budget request for NASA in compliance with the new appropriations account structure;
- developed and submitted to Congress a NASA FY 2009 Congressional justification that complies with the new appropriations account structure;
- identified software, procedure, and report modifications that are required for NASA's core financial systems to comply with the new appropriations accounts;

- tested the interface between the Meta Data Manager that defines the Agency account, program and project structure and the financial system with no identified issues;
- completed unit testing of the financial system, transferring budget in the new structure through the Agency to the Centers and the projects with no identified issues; and
- initiated the first of three rounds of system integration testing (SIT) on July 1. This will test the ability of the system to appropriately manage funds through commitment, obligation, costing and disbursement, as well as accounts payable and receivable.

The remaining required activities are as follows:

- September 2008—complete system integration testing phase; and,
- October 2008—release new system upgrade and associated policies and procedures.

Question submitted by Representative Dana Rohrabacher

Landsat Data Continuity Mission (LDCM)

Q1. The configuration of the Landsat Data Continuity Mission (LDCM), the follow-on to Landsat to be launched in 2011, currently omits the thermal infrared (TIR) imagery capability found on Landsat-7 and on Landsat-5. This capability is of great interest to a wide range of Landsat users, particularly those concerned with managing water resources over the Western region of the US. The only generally equivalent alternative TIR capability currently resides on the Terra satellite. However, that satellite supports a mission with significant differences and priorities from Landsat and cannot effectively provide the flexibility nor the historical continuity a LDCR TIR sensor would offer. Furthermore, Landsats 5 & 7, and Terra have exceeded their design lives.

Thus, what is the likelihood NASA will incorporate a Landsat-equivalent TIR (e.g., a passively cooled microbolometer) onto the LDCM or onto a similar spacecraft to be operational in the 2011 timeframe?

A1. Launch of a thermal infrared imaging capability in 2011 is unlikely. Currently, NASA does not have the funding for a thermal imager, nor was a requirement for thermal imaging included in concept development for the LDCM, though accommodations for a thermal-type instrument have been included in the LDCM spacecraft contract. Recent heightened interest in thermal data has led NASA to explore options for thermal infrared imaging, and this work is ongoing. Approaches to a thermal imaging capability are being considered, and will be outlined in the report submitted to Congress regarding LDCM data continuity as requested in the Explanatory Statement accompanying the *FY 2008 Consolidated Omnibus Appropriations Act* (P.L. 110–161). NASA anticipates submitting this report to the Subcommittee in the July timeframe. In early/mid CY 2009, LDCM will complete a Mission Confirmation Review and consistent with NASA management policies for space flight missions, a firm cost and schedule commitment will be made following that review. Once confirmation is complete, it is likely that the launch date for LDCM, as currently defined, will move beyond the 2011 date identified in the early concept phase and listed in the FY 2009 budget request.

Appendix 2:

Additional Material for the Record

NASA Report

to

Committees on Appropriations

regarding

Alpha Magnetic Spectrometer (AMS)

February 2008

NASA Report

to

Committees on Appropriations

Regarding

Alpha Magnetic Spectrometer (AMS)

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I. Introduction

The following direction for NASA was included in the Explanatory Statement accompanying the FY 2008 Omnibus Appropriations Act (P.L. 110-161):

"The Administrator is directed to study the possibility of delivering the Alpha Magnetic Spectrometer (AMS) to the International Space Station. Not only will this mission enable researchers to prepare NASA and our international partners for future space exploration, it has widespread support in Congress. This study shall be submitted to the Appropriations Committees within 30 days of enactment of the Act and should include the steps necessary to prepare for such a mission."

In response to this direction, the enclosed study will address the technical and programmatic steps necessary to deliver the AMS to the International Space Station (ISS). Specifically, the study will address the completion of AMS experiment development, launch preparation activity (including integration onto a launch vehicle), delivery to the ISS, and integration with the Station. These steps and associated schedules will be summarized in section IV.

II. Background and current status

The AMS science experiment was selected by the U.S. Department of Energy (DOE) Office of Science in 1995. DOE is the sponsor of the 16-nation AMS International Collaboration that is responsible for AMS experiment development and testing. NASA signed a 10-year Implementing Arrangement (IA) with DOE in 1995, agreeing to integrate and launch AMS on the Space Shuttle twice: first, on a science and engineering test flight which was successfully accomplished on STS-91 in 1998, and second, to the International Space Station (ISS) to be installed as an externally attached payload. In the aftermath of Columbia and with the 2005 expiration of the AMS IA, DOE was notified that NASA would not be able to launch AMS on the Space Shuttle to the ISS due to technical and schedule constraints associated with the critical support of the ISS. NASA notified DOE subsequently that NASA AMS Shuttle/ISS integration activities would continue as long as these activities remained viable.

The AMS flight hardware (including the 2,500-liter superfluid helium tank, cryocoolers, and other associated hardware) was designed to support a baseline three-year science mission aboard ISS. AMS can also continue to support some minimal science operations once the helium supply is exhausted AMS in total weighs 15,100 lb (6,860 kg) including the experiment and NASA integration hardware, and has a volume of approximately 1,800 cubic ft (51 cubic m).

Figure 1 shows an artist's rendering of AMS deployed on the ISS. Figure 2 shows a cut-away view of AMS.

Completion of AMS Experiment Final Assembly

Final assembly of the AMS experiment began in August 2007, in a dedicated AMS clean room at the European Center for Nuclear Research (CERN). As part of this process, the AMS particle detector flight hardware and associated electronics and fluid piping were installed (see Figure 3). According to the current schedule, all of the detectors will be completely integrated by February 2008. The remaining major systems to be installed are the radiators and the flight magnet. These items are scheduled to arrive at CERN in May 2008. Once these items have been installed, along with their control electronics and fluid supplies, the payload will undergo a series of functional checkouts before being released for final experiment calibration.

Final Experiment Calibration

Current plans call for AMS to undergo high-energy particle beam testing at CERN in the October-November 2008 timeframe. This testing will ensure that data recorded by AMS are optimized. Use of CERN Accelerator Beam Facilities has already been coordinated with the CERN management by the AMS International Collaboration. During final assembly, functionality of the experiment's particle detectors will be checked out using cosmic rays. While this provides acceptable detector calibration, it does not provide the precise calibration required for AMS science because of the low incidence and unknown momentum of cosmic rays. The dedicated test beam available at CERN will address this by providing a beam of artificial particles of known composition and momentum over a wide range of entry angles into the AMS experiment. Based on the AMS team's long experience with particle beam tests, this calibration activity is estimated to require approximately one month.

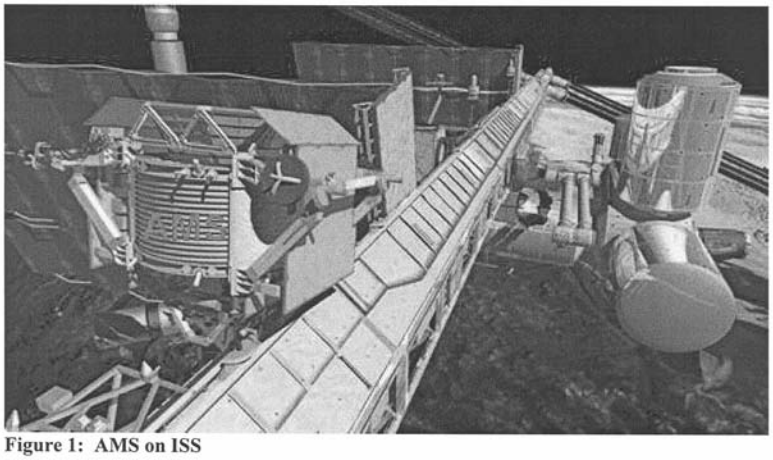


Figure 1: AMS on ISS

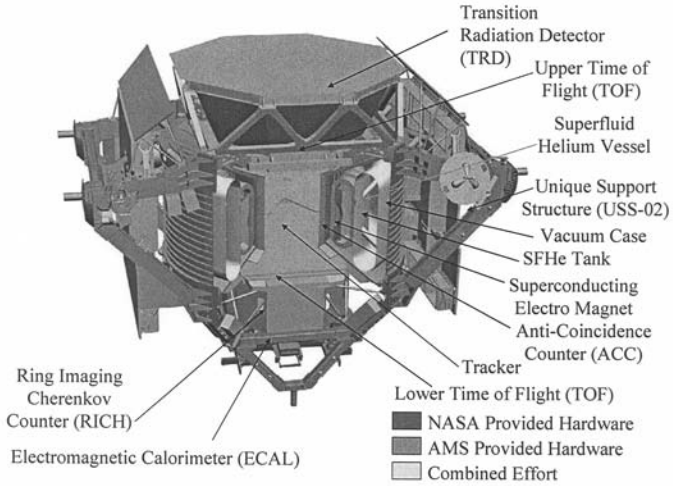


Figure 2: Cut-away View of AMS Showing Experiment Detectors

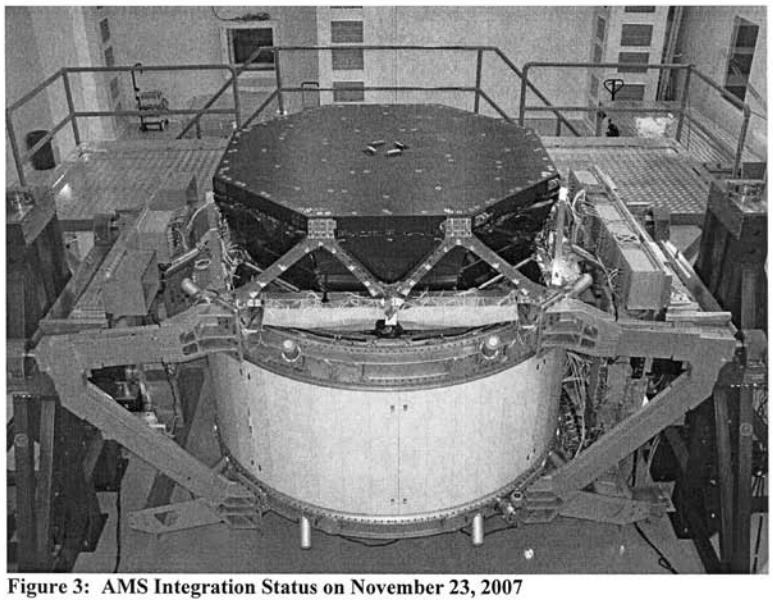


Figure 3: AMS Integration Status on November 23, 2007

Thermal/Vacuum Testing

The AMS payload will be tested for approximately 30 days in the European Space Agency (ESA) Large Space Simulator at Noordwijk, The Netherlands, in the December 2008 timeframe. Use and funding of the ESA facilities has already been coordinated with ESA by the AMS International Collaboration. The primary purpose of this test is to show that AMS can survive and operate under vacuum conditions. During three hot-cold cycles, the AMS thermal interfaces will be verified, thermal control systems thoroughly tested, and all electronics operated. A thermal balance test will be performed to help correlate the thermal model in order to better understand AMS on-orbit thermal behavior.

AMS Transport to the NASA Kennedy Space Center

Following successful thermal/vacuum testing, the AMS experiment is expected to be delivered to the NASA Kennedy Space Center (KSC), Florida, no earlier than 2009. The AMS International Collaboration will have the responsibility for shipment of AMS to KSC. In the interim, while awaiting delivery to KSC, AMS will undergo additional experiment calibration in Europe as time allows.

III. NASA AMS Integration Readiness

The FY 2008 NASA AMS Integration budget covers only the integration of the AMS onto the International Space Station (ISS) as an externally attached payload, and the option of integration onto the Space Shuttle, but not the launch of the payload.

III.A. Steps for NASA AMS Launch Integration

III.A.1. Hypothetical Shuttle Launch Integration

NASA AMS-Space Shuttle Integration Flight Hardware Delivery

The NASA AMS integration flight hardware, which has already been developed and delivered to CERN, has three primary functions. The NASA integration hardware would provide the structural, thermal, and avionics interfaces between both AMS and the Space Shuttle, and AMS and ISS. Combining ISS/Shuttle/AMS experiment interface functions, the NASA integration hardware is relatively lightweight (3,800 lbs./ 1,700 kg), increasing the ability to co-manifest the AMS in a Space Shuttle payload bay while displacing the minimum of critical ISS cargo items on the same flight. A similar lightweight NASA AMS integration hardware design approach enabled an earlier version of the experiment to be successfully co-manifested with space station Mir components on the STS-91 Space Shuttle flight in 1998. The relatively early delivery of the NASA integration flight hardware to CERN for incorporation into the overall AMS experiment final assembly process reflects the integral role of the NASA integration flight hardware in the AMS experiment design (see Figure 4).

The AMS cryogenic superconducting electromagnet system at the heart of the AMS experiment must operate in a vacuum. The required pressure control to support this is provided by the NASA-built cylindrical Vacuum Case. This Vacuum Case is, in turn, attached to the NASA-built Unique Support Structure (USS-02). Together, these two NASA flight hardware items provide attachment points for the entire AMS experiment as well as the Space Shuttle. At the bottom of the USS-02 is the NASA-built Payload Attachment System, a triangular structure which is the experiment's primary structural interface with the ISS. While AMS is in the Shuttle, power and data services from the Space Shuttle would come through the Remotely Operated Electrical Umbilical mounted on the front starboard side of the USS-02. The NASA-provided Flight Releasable Grapple Fixture would transfer AMS out of the Shuttle's payload bay. During the transfer from Shuttle to ISS, power and data services would be provided through a NASA-provided Power and Video Grapple Fixture mounted on the USS-02. Finally, on ISS, power and data for the AMS experiment would be provided through the NASA Umbilical Mechanism Assembly mounted on the lower part of the USS-02.

Safety Integration (Flight Safety/ Launch Site Safety)

In May 2007, the AMS project successfully completed the Phase II flight safety process. In the Phase II review, the NASA Flight Safety organization critically reviewed the design, operation and verification processes of the AMS and found it compliant with all documented requirements for safe flight aboard a Space Shuttle and delivery to the ISS. Also at this review, AMS compliance with ISS safety requirements was reviewed and approved. The final Phase III safety review (currently set for early FY 2009) is scheduled to report on the progress of any remaining safety verifications noted during Phase II. No major flight safety issues are anticipated for flying AMS on a Space Shuttle.

The AMS ground safety process Phase II review is scheduled to be completed in May 2008. During this review, the operations of the AMS and associated ground support equipment will be assessed for compliance with KSC safety requirements. This KSC review relies heavily on safety compliance documentation already provided to the NASA Johnson Space Center (JSC) flight safety review to resolve any issues directly associated with the AMS flight hardware. The Phase III Ground Safety Review for AMS (currently anticipated for early calendar year 2009) will document the final procedures for, and required verification of, safety compliance. No major ground safety issues are anticipated for AMS.

Analytical and Operations Integration

A preliminary AMS Mission Integration Plan has been developed. This plan documents all of the requirements of AMS and the Space Shuttle programs. The AMS and Shuttle programs are moving forward to develop, by early 2009, all required analytical and operations data to support an AMS launch on the Space Shuttle. This data will be coordinated with the ISS Program as required. No major analytical/operations integration issues are anticipated for AMS.

Potential for Manifesting AMS on a Currently-Planned Shuttle Flight

All remaining Space Shuttle flights to the ISS are fully manifested with critical items needed to complete assembly of the ISS and to preposition sufficient spares and associated stowage hardware onboard the Station for post-Shuttle operations. NASA has prioritized Space Shuttle payload space and the flight sequence to focus on delivering hardware and supplies to sustain the ISS; all available Space Shuttle capacity through program retirement in September 2010 will be needed to accomplish this task. The remaining Space Shuttle flights to ISS, 10 assembly and logistics flights plus up to 2 contingency flights that could be added to the manifest(if they can be safely flown before September 2010), are fully subscribed with these critical payloads. The recent issues with the alpha and beta solar array joints on the ISS demonstrate the criticality of maintaining the flexibility of manifesting additional spares and supplies on these last few Space Shuttle flights. Pre-positioning spares in 2009-10 will facilitate ISS operations after Shuttle retirement and before commercial cargo services are available to support the

Space Station. This helps reduce dependence on Russia and facilitate continued Space Station activities in support of exploration and science.

The AMS experiment would occupy roughly 43 percent of a Shuttle's payload capacity by weight, and roughly 25 percent by volume. While AMS would not necessarily require a dedicated Shuttle flight, manifesting AMS on a Shuttle flight would require bumping other selected, critical ISS hardware and/or supplies that were planned for that flight. If the decision were made to bump critical ISS hardware and spares in favor of AMS, then AMS would have to be manifested on a currently-planned Space Shuttle flight no later than February 2009.

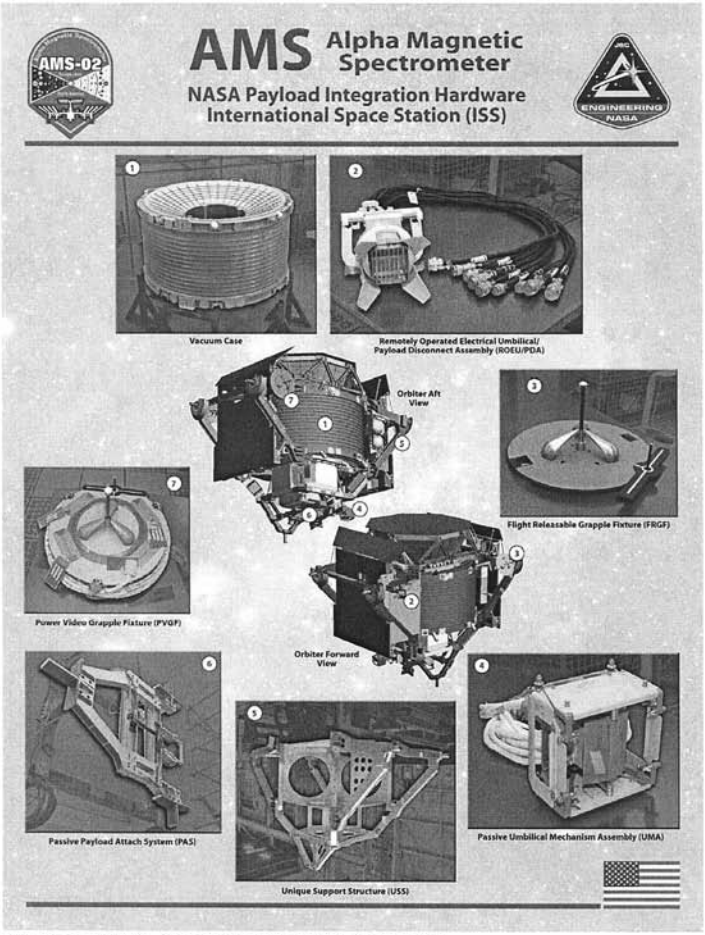


Figure 4: NASA-Provided Integration Hardware

Potential for Manifesting AMS on an Additional Shuttle Flight

Adding another Space Shuttle flight to the manifest would be difficult, costly, and would have a significant negative impact on NASA's exploration program.

The high fixed costs of yearly Space Shuttle operations and the need to protect critical Space Shuttle capabilities in the event of a launch delay make it very difficult to extend the manifest part way into a new fiscal year without accruing nearly all the costs of the entire year. Flying the Space Shuttle safely requires multiple production and operations contractors whose unique capabilities must be maintained through the last flight of the program. Those contracts have been aligned to conclude with the end of the Space Shuttle program in FY 2010. The costs of re-opening those contracts to add an additional flight in FY 2010 would be substantial, with preliminary estimates on the order of $300 – 400 million. The costs of re-opening contracts and maintaining the capability of flying the Space Shuttle into FY 2011 (including the need to protect capabilities if a launch delay pushed the flight beyond the first quarter) would be even more substantial, with preliminary estimates on the order of approximately $2.7 – 4.0 billion. These costs would come directly at the expense of exploration development activities. Also, since exploration needs facilities and workforce that are currently dedicated to Space Shuttle operations, any delay in Space Shuttle retirement would have a significant negative impact on exploration development activities and further exacerbate the strategic gap in U.S. human spaceflight. In terms of schedule, mission-planning activities begin approximately 18 months prior to launch. This means that, if a major change needs to be made to the end of the Space Shuttle manifest prior to retirement in FY 2010, a decision to add an additional Space Shuttle flight would have to be made no later than February 2009.

In summary, the existing Space Shuttle flight schedule, and potentially up to two contingency logistics flights, may be achievable before FY 2010 retirement. However, the program does not have a significant amount of margin to accommodate an additional flight for AMS without significant impacts to future exploration goals, cost, and possibly safety.

III.A.2. Hypothetical ELV Launch Integration

Summary of Early Studies

In early 2006, NASA studied alternative launch options using ELVs to launch AMS to the ISS. Specifically, NASA reviewed a number of alternatives, including existing U.S. ELVs, European ELVs, Russian ELVs, potential Commercial Orbital Transportation Services (COTS)-derived vehicles, and the Japanese H-II Transfer Vehicle (HTV). One proposal even considered a combined Shuttle and ELV alternative that would reduce the cost of the spacecraft required to carry AMS to ISS because the approach would have used the Shuttle as a ferry between the AMS spacecraft and the ISS. At the time of these studies, the AMS development was still in the design phase, with much of the flight hardware not yet fabricated. Even at that point, it was determined that AMS could not fly on these alternative launch vehicles without major modifications to the NASA-built carrier/upper stage. Total cost for a U.S. ELV launch option was then estimated to range from $440-564 million, while the estimated cost for the Japanese HTV option ranged

from $254 million (which included a rebate for a barter arrangement with the Japanese) to $380 million. Most of the ELV options resulted in estimated AMS schedule delays of at least two years to 2011, depending on launch vehicle availability (the ELV option involving a Shuttle rendezvous would have resulted in a launch delay to 2010).

Current Potential for AMS Manifesting on an ELV

Since the completion of the AMS alternative launch studies in 2006, the AMS development effort has completed design and flight hardware fabrication phases, subcomponent testing, and is now in the final assembly and testing phase. While some of the earlier ELV launch options are still theoretically available (for example, a non-standard Japanese HTV, or a non-standard COTS-derived vehicle), retrofitting the AMS for an ELV launch to the ISS at this point would likely involve the disassembly of the experiment, and subsequent retesting, redesign, modification and/or replacement of finished AMS flight hardware. This is because the NASA-provided AMS ISS/Shuttle integration hardware is also an integral part of the AMS experiment itself in terms of handling structural loads and thermal conductivity. To access the NASA integration flight hardware for ELV retrofitting would require, literally, taking the AMS experiment apart at over 900 physical interfaces to enable flight hardware modification and/or replacement. The early 2006 ELV studies' cost range of $254-564 million would likely now approach $1.0 billion or more if additional disassembly, retesting, redesign, modification, and/or replacement of much of the $1.5 billion AMS experiment flight hardware is required (see Figure 5). A recent United Launch Alliance proposal identified three different ELV architectures that might lift AMS to orbit without disassembly of AMS, ranging in price $200-290 million. When these costs are combined with the costs to develop a spacecraft bus able to meet both AMS power/communications requirements and ISS visiting vehicle requirements, and the costs to recertify AMS for launch on the new vehicle, overall mission costs would approach $570-600 million. The AMS launch schedule would likely be delayed to at least 2013 or 2014, two-three years or more beyond the 2011 estimate associated with those earlier options remaining theoretically available. Moreover, launching in that timeframe implies that the three-year minimum AMS science mission on ISS may not be completed by FY 2016, when current projections show ISS operations funding terminated.

In summary, the technical complexity of a hypothetical alternative AMS launch option to ISS involving ELVs has increased, making it much more difficult to retrofit the AMS experiment to an ELV. NASA has no funding to retrofit AMS for an ELV launch to ISS. If NASA were required to do so, the funding needed to accomplish such AMS ELV retrofitting would damage other established and agreed-upon NASA priorities.

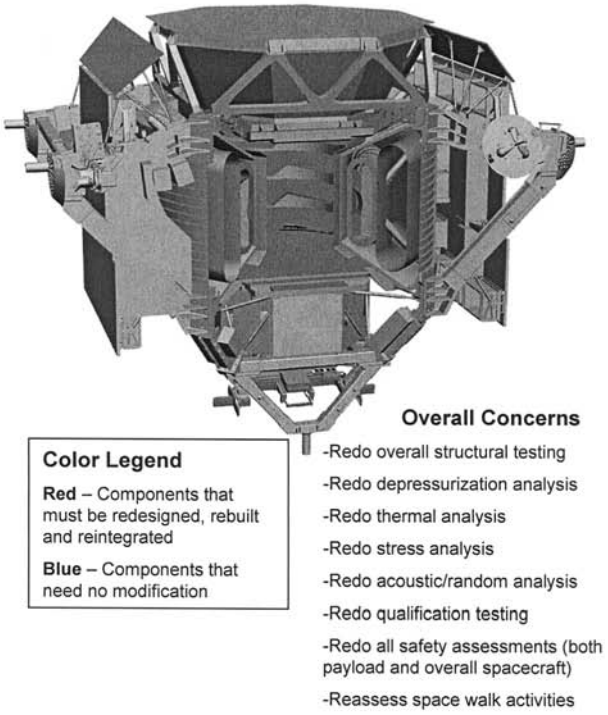


Figure 5: AMS Required Flight Hardware Changes for Hypothetical ELV Launch to ISS (updated since the early 2006 studies)

III.B. Steps for NASA AMS ISS Integration

ISS S3 Truss Installation

In June, 2007, the ISS S3 Truss segment was successfully added to the ISS during the STS-117 Shuttle flight. The S3 Truss has four external mounting locations; one of these locations could be the final mounting point for AMS. With the installation of the ISS S3 Truss segment, there is now sufficient ISS infrastructure in place to physically interface with the AMS experiment once launched. Figure 6 shows the S3 truss installed on-orbit.

AMS Safety Integration

As discussed in section III.A.1, the AMS flight safety process for operations aboard the ISS has successfully passed the most critical of the three required phases of safety review -- the Phase II review in May of 2007. The combined NASA Space Shuttle/ISS Flight Safety organization has critically reviewed the design, operation, and verification processes of the AMS and found them compliant with all documented requirements for safe operations aboard the ISS. The remaining safety review, known as the Phase III review (currently anticipated for early 2009), will report progress on open items from the Phase II review. No major flight safety issues are anticipated for AMS operation on the ISS.

The ISS has no unique requirements for ground processing safety; these are established by the launch vehicle and its host location.

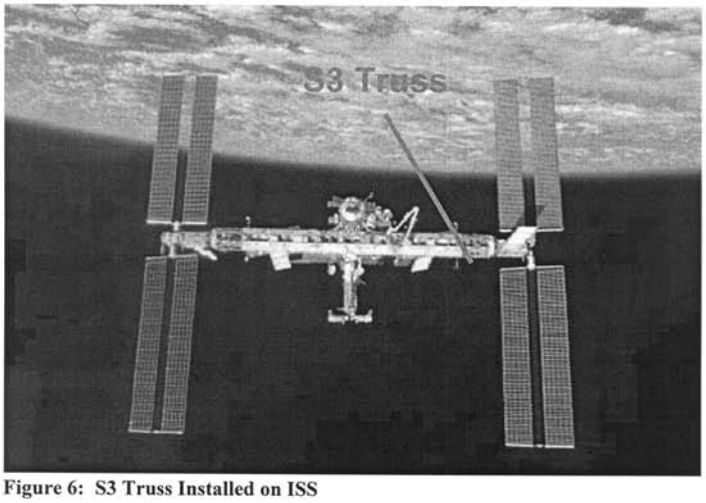


Figure 6: S3 Truss Installed on ISS

ISS/AMS Analytical/Operations Integration

The ISS Program and AMS Program have been working since 1999 to develop all necessary analytical and operations integration approaches and documentation. All AMS requirements are fully defined, and the AMS Program is working to verify that the requirements are being met. The ISS Program continues to support the AMS Program as needed to complete all necessary tasks to make AMS ready for its mission on ISS. In addition, the ISS Program will coordinate AMS analytical/operations integration planning

with the Shuttle Program as required. No major ISS analytical/operations integration issues are anticipated for AMS operations on ISS.

ISS Power Availability

The ISS S3 Truss sites have adequate power interfaces to support AMS power needs once AMS is deployed on ISS. AMS requires 2,400 Watts of power on average and a peak of 2,800 Watts of power. Available ISS power resources would be sufficient for nominal AMS science operations.

ISS Data Availability

The ISS currently has adequate resources on-orbit to support AMS data needs. The AMS requires 2 Megabits per second of data on a continuous basis. The ISS can provide a data stream of 50 Megabits per second. In the event that AMS does not receive continuous data downlinks to Earth, AMS can store data on-orbit and burst the data down at rates as high as 40 Megabits per second.

ISS crew availability

Since AMS command and telemetry would be operated from the ground, only minimal crew interaction would be required for the initial robotic installation of the AMS on the ISS S3 Truss. As such, ISS crew resources would be sufficient for AMS.

In summary, there are no major ISS integration issues regarding AMS at this time.

IV. Summary of Steps Necessary to Deliver AMS to the ISS (see Table 1)

AMS continues to meet its internal project milestones for integration. Final payload integration is scheduled to be completed by early 2009.

However, the Space Shuttle manifest is fully subscribed with hardware and supplies needed to safely maintain the ISS in the post-Shuttle era. Manifesting AMS on one of the few remaining scheduled Space Shuttle flights would mean bumping other selected, critical ISS hardware and spares needed to maintain the ISS after September 2010. There are currently no Space Shuttle payload opportunities for AMS available before program retirement in September 2010. Adding an additional Space Shuttle flight to the manifest before September 2010, assuming contracts could be reworked, sufficient parts could be built and the schedule would allow such a change, would cost approximately $300-400 million and would mean accepting additional schedule and programmatic risk in the Shuttle program. Adding an additional Space Shuttle flight to the manifest after September 2010 and maintaining the infrastructure needed to safely fly the Space Shuttle into FY 2011 would cost approximately $3-4 billion, and have both a significant negative impact on NASA's exploration program and the potential of adding additional safety risks to the Space Shuttle program. In order to meet the 18-month mission planning lead time requirement, a decision to either manifest AMS on a currently-planned Space Shuttle flight or to add a new Space Shuttle flight for AMS would have to be made no later than February 2009.

Modifying the AMS hardware at this late stage to fly on an ELV would delay the launch until 2013 or 2014 and add at least an additional $0.57-1.0 billion to the cost of the project. No actions have been taken to modify the AMS hardware to launch on an ELV, and NASA has no budget to do so. Moreover, a 2013 or later ELV launch implies that the baseline AMS three-year science mission on ISS may not be completed by FY 2016 when current projections show ISS operations funding terminated. If NASA is required to retrofit AMS for an ELV launch to ISS, the funding needed to accomplish such an AMS ELV retrofit would damage other established and agreed-upon NASA science priorities.

NASA will continue to keep the Congress informed regarding AMS status.

Table 1 - Summary of Steps Necessary to Deliver AMS to the ISS

Steps Necessary	Funding Responsibility	Timeframe (in calendar years)
AMS Experiment Development Readiness for Launch		
- Completion of AMS Final Assembly	International/DOE	Late 2008
- Final Experiment Calibration	International/DOE	Late 2008
- Thermal Vacuum Testing	International/DOE	Late 2008
- AMS Transport to KSC	International/DOE	No earlier than 2009
NASA AMS Integration Readiness		
Shuttle Launch		
- NASA Integration Flight Hardware	NASA	Completed
- Safety Integration (Flight & Launch Site Safety)	NASA	Early 2009
- Analytical & Operations Integration	NASA	Early 2009
- Hypothetical AMS Manifesting Decision regarding a Currently-Planned Shuttle Flight	NASA	NLT February 2009
- Hypothetical AMS Manifesting Decision regarding a New Additional Shuttle Flight in FY 2010 or FY 2011	Unfunded	NLT February 2009
ELV Launch		
- Prior ELV Studies in early 2006	NASA	Completed
- Hypothetical AMS Manifesting Decision regarding an ELV (Updated since 2006 studies)	Unfunded	Launch 2013-2014 or later
ISS Integration		
- ISS S3 Truss Installation On-Orbit	NASA	Completed
- NASA AMS Integration Flight Hardware Delivery (Combined with Shuttle Hardware)	-	-
- Safety Integration (Combined with Shuttle Safety Integration)	-	-
- Analytical & Operations Integration (Combined with Shuttle Analytical Integration)	-	-
- ISS Power Availability	NASA	Completed
- ISS Data Availability	NASA	Completed
- ISS Crew Availability	NASA	Completed

NASA MATERIAL FOR THE RECORD

March 2008

Assessment of Chinese Capabilities to Mount a Human Lunar Mission

Chinese space officials have openly discussed plans to conduct space walking demonstrations next year, orbital rendezvous and docking operations by 2010, and a robotic lunar landing mission by 2012. Based upon a careful review of open source information concerning the capabilities of the *Shenzhou* crew vehicle and the planned *Long March 5* rocket, it is my considered judgment that, although China's public plans do not include a human lunar landing, China will have the technical wherewithal to conduct a manned mission to the surface of the Moon before the United States plans to return.

While initial Chinese mission(s) to the Moon would not have the long-term sustainability of our own plans for lunar return, I believe China could be on the Moon before the United States can return.

China is prosecuting a fully indigenous program of human space flight development. They have adapted the design of the Russian *Soyuz* vehicle to create their own *Shenzhou,* which is more spacious, more capable, and better suited for long duration space missions than its Russian antecedent. China plans to conduct its first space walks and orbital rendezvous operations in 2008 and 2010, and to build a small space station in the next few years. All of this has been openly announced. Their accomplishments so far give me no cause to doubt their ability to carry out these plans.

With the first manned *Shenzhou* flight in October 2003 China surpassed by itself the accomplishments of all six U.S. *Mercury* missions in the early 1960s. The second *Shenzhou* flight in 2005 demonstrated most of the accomplishments of the first three U.S. *Gemini* missions in 1965. They will soon demonstrate the rendezvous and docking capabilities pioneered by the U.S. in the *Gemini* program in 1966, by docking a *Shenzhou* spacecraft with another *Shenzhou,* or with an orbital module left by a prior mission.

These examples illustrate a fundamental difference between the development of the Chinese human space flight program, and that of the U.S. and Russia. Because China can follow established technical paths, they do not have to verify the basic feasibility of their approach. They need only to demonstrate that their systems work as designed to accomplish tasks which are by now well understood. Thus, each step in space can take them to a new capability plateau, eclipsing the equivalent of several pioneering but tentative steps in an earlier era. The United States required twenty-one human space flights to reach the Moon in the 1960s. China should not need so many.

The second major initiative for which the Chinese have demonstrated significant progress is the development of the *Long March 5* launch vehicle. They have conducted several rocket engine tests over the past two years, and plan to conduct demonstration flights in 2008–11. The Chinese have advertised its capability as 25 metric tons (mT) to low Earth orbit (LEO), rivaling or surpassing the largest expendable launch vehicles available today, which have a capacity of approximately 20 mT, or slightly greater. I believe that China's concerted, methodical approach to the *Long March 5* development, along with recent construction of a new launch facility on Hainan Island, puts them on track to bring the *Long March 5* online by 2013–14, their stated intention. NASA's *Ares I* rocket, which will have similar capabilities, will not be fully functional until March 2015, according to current plans.

Third, China has developed and demonstrated a dual launch processing capability. This capability, together with the 25 mT-to-LEO capacity of the *Long March 5,* allows China to reach the "tipping point" critical to executing a manned mission to the Earth's Moon. As one possible approach, this can be done by means of two dual-launch sequences.

The first *Long March 5* would place, in Earth orbit, a lunar lander similar in size and mass to the Apollo Lunar Module, about 14 mT, together with a lunar orbit injection (LOI) stage weighing 6 mT. With a second *Long March 5* launch, the lander and LOI stage would be joined in Earth orbit by a 25 mT Trans-Lunar Injection (TLI) stage. The two payloads would rendezvous and dock automatically, as the Russian *Soyuz* and *Progress* vehicles do at the International Space Station today. After docking, the TLI stage would send the combined payload to the Moon. Injection into lunar orbit would be accomplished by the LOI stage, leaving the lander poised to wait for a few weeks—or even months if necessary—for the second launch sequence.

The second pair of *Long March 5* launches would place in Earth orbit a crewed *Shenzhou* vehicle and LOI stage with one launch, and a TLI stage with the other. As in the earlier sequence, the *Shenzhou* would rendezvous and dock with the TLI stage, which would send the combined stack to the Moon. The LOI stage would decelerate the *Shenzhou* into lunar orbit, where it would then dock with the waiting lander. The *Shenzhou* would differ from today's Earth-orbital version in two respects. It would require larger propellant tanks to allow it to depart lunar orbit for the return to Earth, and it might require a thicker heat shield to withstand atmospheric entry upon return from the Moon. Neither of these modifications presents a significant challenge. The lunar version of *Shenzhou* would weigh about 11 mT, considerably less than the 14 mT lunar lander, so the delivery of a lunar-capable *Shenzhou* to lunar orbit presents no difficulty.

After rendezvous, the *Shenzhou* crew would transfer to the lander, land on the Moon's surface, remain for several days, depart, rendezvous again with the *Shenzhou,* and return to Earth. (Parameters and assumptions for this scenario are summarized in the attached Technical Notes.)

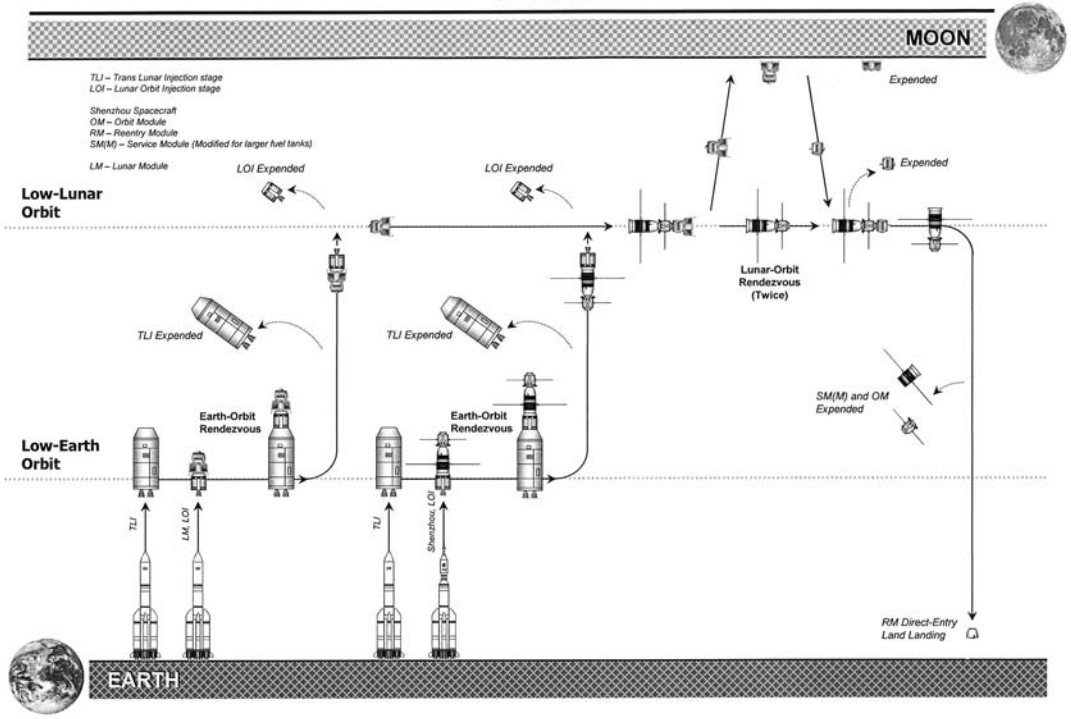
What is fundamentally different about the dual-launch capability that the Chinese have demonstrated, and could well develop for the *Long March 5,* is that it enables human lunar missions without requiring a 120 mT class vehicle like the Apollo-era *Saturn V,* or our planned Shuttle-derived *Ares V.* This technique is not particularly cost-effective and is not easily scaled to a sustainable operation, but it does offer a path to "boots on the Moon" without the development of a heavy-lift launch vehicle.

Apart from the lunar lander itself, this approach requires for its implementation only modest developments beyond the existing *Shenzhou* and the *Long March 5* vehicles. The new elements for a lunar mission are the TLI and LOI stages, which would be essentially the same aside from the size of the propellant tanks employed, and which would utilize the upper-stage engines from the *Long March 5,* with modest improvements. This is a minor developmental excursion from *Long March 5* technology.

China has not announced any intention to develop a human lunar lander. However, I note that China recently launched its first robotic lunar orbiter mission, and has announced plans for a robotic lander by 2012 and a robotic sample return mission in the 2017–2020 timeframe. The developments in communications, tracking, guidance, navigation, and control required to execute robotic lunar orbital and lander missions are identical to those for a manned system, irrespective of whether or not the lander itself is scalable to human missions. Inasmuch as the design parameters of the Apollo lunar lander are widely known and well within today's state-of-the-art, the development of a similar vehicle by the Chinese should not present a significant problem.

Pending development of a Chinese manned lunar lander, a fly-by or orbital mission around the Moon could easily be executed with the *Shenzhou* spacecraft and a single pair of *Long March 5* launches, as outlined above. Indeed, as a matter of prudent engineering development, I would fully expect China to execute such a mission prior to a lunar landing. This would be completely analogous to the inspirational *Apollo 8* mission during the Christmas season of 1968.

Technical Notes

Mission Parameters		
Translunar Injection □V (km/s)	3.1	
Lunar Orbit Injection □V (km/s)	1.0	
Trans-Lunar Injection		
TLI Stage Gross Mass (mT)	25.0	*Long March 5* payload to LEO
TLI Stage Mass Fraction	0.9	U.S. Centaur upper stage > 0.9
TLI Stage Empty Mass (mT)	2.5	
TLI Propellant Mass (mT)	22.5	
Specific Impulse (I_{sp}, seconds)	450	Modest improvement of YF-75
Net Payload to TLI (mT)	20	
Lunar Orbit Injection		
Lunar Lander Mass (mT)	14	Apollo Lunar Module Mass
LOI Stage Gross Mass (mT)	6.0	
LOI Stage Mass Fraction	0.83	Conservative assumption
LOI Stage Empty Mass (mT)	1.0	
LOI Stage Propellant Mass (mT)	5.0	
LOI Injection Stage I_{sp} (seconds)	450	Same as TLI Stage
Lunar Shenzhou		
Earth Orbital Shenzhou Mass (mT)	8.0	
Lunar Departure □V (km/s)	1.0	
Lunar Departure Propellant Mass (mT)	2.7	Hypergolic propellants, 310 s I_{sp}
Additional Propellant Tank Mass (mT)	0.3	10% of propellant mass
Total Lunar Shenzhou Mass (mT)	11.0	Less than 14 mT lunar lander

NASA Concept of Notional Chinese Lunar Landing CONOPS