NASA'S FISCAL YEAR 2010 BUDGET REQUEST

HEARING

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

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NASA'S FISCAL YEAR 2010 BUDGET REQUEST

TUESDAY, MAY 19, 2009

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

The Committee met, pursuant to call, at 2:05 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Bart Gordon [Chairman of the Committee] presiding.

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

Hearing on

NASA's Fiscal Year 2010 Budget Request

May 19, 2009
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

WITNESS LIST

Mr. Christopher Scolese
Acting Administrator
National Aeronautics and Space Administration

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HEARING CHARTER

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

NASA's Fiscal Year 2010 Budget Request

TUESDAY, MAY 19, 2009
2:00 P.M.–4:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Tuesday, May 19, 2009 at 2:00 p.m., the Committee on Science and Technology will hold a hearing on the National Aeronautics and Space Administration's (NASA) Fiscal Year 2010 Budget Request, NASA's proposed Fiscal Year 2009 Operating Plan, and use of funds provided through the Recovery Act.

Witness:

Mr. Christopher Scolese
Acting 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 projected civil service workforce for FY 2009 is 17,900 employees. NASA has ten field Centers, including the Jet Propulsion Laboratory (JPL), a Federally Funded Research and Development Center (FFRDC). NASA conducts research and development activities in a wide range of disciplines including aeronautics, astrophysics, heliophysics, planetary science, Earth science and applications, microgravity research, and long-term technology development. NASA also operates a fleet of three Space Shuttles and is assembling and operating the International Space Station (ISS). NASA is undertaking an exploration initiative with the goals of developing a new human space transportation system for both low-Earth orbit and for missions beyond low-Earth orbit, returning American astronauts to the Moon by 2020, and carrying out a broad program of human and robotic exploration of the solar system. NASA also maintains a space communications network that supports both NASA missions and other federal agency requirements. As of 2007, the most recent date for which complete data are available, about 82 percent of NASA's budget was for contracted work. In addition, a number of NASA's scientific and human space flight activities involve collaboration with international participants.

Budgetary Information

NASA's proposed budget for FY 2010 is $18.7 billion, an increase of 5.1 percent over the enacted FY09 appropriation for NASA. The FY10 budget projection for NASA beyond FY10 is essentially flat through FY13. Attachment 1 summarizes the FY10 budget request and its five-year funding plan. In addition, The *American Recovery and Reinvestment Act* [P.L. 111–5], included $1 billion for NASA's Earth science, aeronautics exploration programs, cross-agency support, and Inspector General. Recovery Act funds are to be expended by September 30, 2010.

The President's request for FY10 continues the budgetary structure that was introduced for the FY09 budget and is presented in seven accounts—Science; Aeronautics; Exploration; Space Operations; Education; Cross Agency Support; and Inspector General. As part of the budget restructuring that was introduced with the FY09 President's request, 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. 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 *Vision for Space Exploration* introduced by President Bush in 2004 with the actual funds requested for NASA. As can be seen, previous budget requests for NASA have been significantly less (i.e., typically on the order of a half-billion dollars or more in the early years) than what was projected as being needed to carry out the Exploration initiative and NASA's other core missions. The cumulative shortfall over that period is in excess of $4 billion. The additional funding provided in the FY09 appropriation and the FY10 budget request help to redress that shortfall. However the FY10 budget request does not project growth for the NASA budget beyond FY10, and the disparity between the 2004 budget projections for FY11–FY14 that the Agency was planning against and the budgets that are now being proposed through FY 2014 is shown in the chart. In addition, the impact of the budgetary shortfalls since 2004 has been exacerbated by the requirement to absorb the cost of the Shuttle's return-to-flight following the *Columbia* accident, the additional cost associated with the under budgeting of Shuttle transition and retirement that occurred in the FY05 budget plan, and the under budgeting of ISS program support that also occurred in the FY05 budget plan, which NASA indicates resulted in an unfunded lien against the Agency's budgets of about $6.5 billion through FY10

To put the FY10 budget request into context, NASA has been tasked with flying the Shuttle safely until the end of the decade and then retiring the Shuttle fleet; completing assembly of, operating, and utilizing the International Space Station; completing the development of a new Crew Exploration Vehicle/Crew Launch Vehicle by 2015; returning American astronauts to the Moon by 2020; and conducting science and aeronautics programs. The *NASA Authorization Act of 2008* [P.L. 110–422] authorized an FY09 funding level for NASA of $20.21 billion; the FY09 NASA budget request was $17.61 billion and the appropriation for FY09 was $17.78 billion. The Committee is planning to move a multi-year reauthorization of NASA this year.

Acquisition Management

Problems of cost growth and schedule delay in NASA's programs were addressed in the past two NASA Authorization Acts. Specifically:

- Provisions in the *NASA Authorization Act of 2005* [P.L. 109–155] were enacted to help NASA and Congress spot potential cost growth and schedule problems early in the development phase of a major program. Under the 2005 Act, a Baseline Report is required whenever a major program completes required reviews and is approved to proceed to implementation. After completing the Baseline Report, the Act requires NASA to report periodically on a major program through an Annual Report, which is provided as part of the annual agency budget submittal to the Congress, until the program enters operation. The provision defines a major program as an activity with a life cycle cost estimate greater than $100 million. Having established the baseline, the 2005 legislation sets thresholds that, if exceeded, require agency action.
- Concerns regarding the increasing number of Earth and space science missions that were exceeding the 15 percent threshold established in the *NASA Authorization Act of 2005* prompted a requirement in the *NASA Authorization Act of 2008* [P.L. 110–422] for an independent review of the situation. The Act directs the NASA Administrator to arrange for an independent external assessment to identify the primary causes of cost growth in large, medium, and small space and Earth science spacecraft mission classes.

NASA's submission provided in conjunction with the FY 2010 budget indicates that five of eleven projects included in this year's report have had schedule growth in excess of six months from their baseline. Three of these five projects have reported cost growth of 15 percent or more from their baseline. The Mars Science Laboratory reported a 68 percent increase from its baseline development cost estimate, from $969 million to $1.63 billion, and a 26 month delay.

With respect to NASA's contract management practices, NASA remains on the General Accountability Office's (GAO)'s "high risk" list for its contract management practices. Regarding financial management, an independent audit was unable to provide "an opinion on NASA's financial statements for the fiscal years ended September 30, 2008 and 2007." Although the audit found that NASA had improved its internal controls, the auditor (Ernst & Young LLP) disclaimed an opinion due to "continued significant weaknesses in NASA's financial management processes and systems, including issues related to internal controls for property accounting." NASA will need to address other "material weaknesses" identified in the audit.

NASA has taken actions to improve its cost estimating and budgeting process for its space mission acquisitions, and has been recognized by the GAO for its progress in those areas. Acquisition management is an area that the Committee will continue to watch closely. The Subcommittee on Space and Aeronautics held a hearing in March 2009 on NASA's acquisition management and will continue to conduct oversight of this issue.

PROGRAM AREAS

Earth Science

The President's budget for FY10 requests $1.4 billion in direct dollars for Earth science research, applications, Earth observing missions, education and outreach, and technology development, and increase of about $25 million over the FY09 enacted budget. In addition, Earth science received $325 million in Recovery Act funds. When taken together, the Earth Science account represents an increase of over $1.2 billion for the FY09–FY13 period over the previous NASA budget plan, including the Recovery Act funds. The budget proposal for Earth science reflects the Administration's commitment to fund "space-based research that supports the Administration's commitment to deploy a global climate change research and monitoring system." The budget increases for Earth science are aimed at accelerating the development of missions recommended in the National Academies' Earth Science Decadal Survey and on completing development of Earth science "foundational" missions.

Thus far, the Soil Moisture Active-Passive (SMAP) has entered its formulation phase and the Ice, Cloud, and Land Elevation Satellite (ICESat II), will soon enter its formulation phase. The other two missions in the Decadal Survey's first tier of priority, the Climate Absolute Radiance and Refractivity Observatory (CLARREO) and the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI) projects are in the pre-formulation stage (concept study). The FY10 budget also includes $12.9 million in FY10 and about $233 million over FY10–FY13 for Venture-class missions, which will support a program for competitive sub-orbital, airborne, and small satellite projects that was recommended in the Decadal Survey. The augmentation for Earth science has been done, in part, with the goal of accelerating work on the Decadal Survey missions. An issue for the hearing is how much "acceleration" is this funding buying?

NASA has allocated at least $100 million of Recovery funds to support "foundational missions" that are currently in the formulation and implementation phases of development. These missions include the Global Precipitation Measurement (GPM) Mission, the Landsat Data Continuity Mission, and Glory. The FY10 budget proposal does not include funds to re-fly an Orbiting Carbon Observatory (OCO) satellite (or a similar sensor), which was lost due to a launch failure in late February 2009. NASA is analyzing options to re-fly the satellite or a similar sensor and expects to have a decision by late June. NASA would need to reallocate funding among its programs in order to replace the OCO satellite. If NASA were to fund an OCO replacement using funds allocated to SMAP and ICESat II, those satellite mission developments could be expected to slip by roughly two years or more, according to NASA officials.

Other Changes to Earth Science Program Areas

The proposed FY10 provides increases for research and computing over the FY10–FY13 period, as compared to the FY09 enacted budget, but makes modest cuts to technology, Applied Sciences, and multi-mission operations budgets. NASA's Applied Sciences program, involves the development of decision support tools that apply the research results of NASA's Earth science missions to support other federal agency and institutional missions in the areas of climate, ecosystems, agriculture, water, disaster management and other areas that benefit society. How NASA's plans to support decision support tools for stakeholders, especially in the area of climate change, is a potential issue to explore in the hearing.

Research to Operations

The 2005 *NASA Authorization Act* and the 2008 *NASA Authorization Act* directed NASA to coordinate with the National Oceanic and Atmospheric Administration (NOAA) and report on plans for transitioning research sensors and satellites into operational service. In addition, the 2008 Authorization Act directed the Office of Science and Technology Policy (OSTP) to develop a process and to coordinate agency budget requests to enable the transitions. NASA and NOAA have continued to coordinate plans to address climate measurements that were eliminated in the re-

structuring of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program, to acquire the Geostationary Operational Environmental Satellite System (GOES)–R weather spacecraft and instruments, and to plan for Earth science decadal survey missions. NASA has not provided details on the level of resources required to enable effective planning and transition of its sensors and satellites into operations. The hearing could explore this question, especially given the importance for long-range planning on climate monitoring.

Space Science

The President's FY10 budget requests $3.07 billion in direct program dollars (not including Earth science) 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 budget request for space science is about $126.3 million less than the FY09 enacted budget (including the transfer of funding for the lunar precursor robotic program to space science from the Exploration Systems budget). Over the FY10–FY13 period, the Astrophysics budget remains essentially flat, the Planetary Science program is reduced by approximately $100 million, and the Heliophysics budget decreases by about $35 million, as compared to the FY09 budget projection for FY10–FY13.

Space Science topics and issues related to the FY10 budget request include the following:

Program Readjustments to Reflect Budgetary Outlook

While the previous FY09 budget request included new initiatives including a Mars Sample Return mission, an Outer Planets Flagship mission, and a Joint Dark Energy mission, among others, that could not realistically be accommodated within the FY09 budget proposal, the FY10 budget plan for space science no longer includes these or other major new initiatives. For example, NASA selected the Europa Jupiter System target as the focus of an Outer Planets Flagship mission, but elected to proceed with technology development, further definition, and discussions on a potential partnership with the European Space Agency (ESA) on a potential future mission. The FY10 budget plan for planetary sciences does not include a Mars Sample Return mission. NASA officials have indicated their interest in working more closely with ESA on potential Mars missions for the 2016 and 2018 launch opportunities. In addition, NASA is sustaining technology development on potential exosolar planet detection and dark energy missions. NASA has reported that it will base its decisions on which missions to initiate on the results of the National Academies decadal surveys for astronomy and astrophysics and for planetary science that are expected to be finished in 2010 and 2011 respectively.

Research

The FY10 request for Planetary Sciences restructured the program to include a new Lunar Quest budget line, which organizes planetary activities in lunar science, a lunar atmosphere and dust mission, and an International Lunar Network activity into a single program. The FY10 budget request for Lunar Quest is $103.6 million. The status of the International Lunar Network activity is pending the outcome of the Human Spaceflight Review that is described in a later section of the Charter.

The Mars Exploration Program

The FY10 budget requests $416 million for the Mars Exploration Program, an increase of about $116 million over the FY10 request in the previous budget submission. The NASA budget requests an increase of $431.3 million for Mars Exploration over the FY10–FY13 period, as compared to the FY09 budget request, in large part to complete work on the Mars Science Laboratory (MSL) mission. NASA moved MSL's launch date from 2009 to 2011 due to technical problems with the mission. The Management and Performance section of the FY10 budget request reports that MSL experienced a 68 percent cost growth. NASA has stated its interest in cooperating with ESA on future Mars missions. According to NASA officials, the Agency has initiated a review of the Mars architecture.

Aeronautics Research

For FY 2010, NASA is requesting $507 million for aeronautics research, $143 million less than that enacted in FY 2009 (The FY 2009 enacted level includes $150

million appropriated by the Recovery Act). The requested FY 2010 level is about $60 million greater than that projected for FY 2010 in last year's budget submission.

NASA's aeronautics research directly supports the goals and objectives of the National Aeronautics Research and Development Policy signed by the President in December 2006. The budget request funds activities that include (1) foundational research across a number of core competencies that support aeronautics and space exploration activities; (2) research in key areas related to the development of advanced aircraft technologies and systems, including those related to aircraft safety, environmental compatibility, and fuel efficiency; and (3) research that supports the Next Generation Air Transportation System (NextGen). NextGen is a joint effort between the Federal Aviation Administration (FAA), NASA, and the Departments of Defense, Homeland Security and Commerce that will transform the entire national air transportation system, gradually allowing aircraft to safely fly more closely, reduce delays, and providing benefits for the environment and the economy through reductions in carbon emissions, fuel consumption, and noise. The aeronautics budget also funds the Aeronautics Test Program which encompasses the critical suite of aeronautics test facilities needed to conduct aeronautics research.

In FY 2010, the Aeronautics Research Mission Directorate plans to realign its NextGen work to distinguish research conducted on concepts and technologies from that focused on systems analysis, integration, and evaluation. In addition, in FY 2010, NASA plans to establish a program of integrated, system-level focused activities, the first of which will be the Environmentally Responsible Aviation (ERA) Project. ERA's research goal will be the reduction of environmental impacts of aviation in terms of noise and emissions.

Human Space Flight

NASA's Human Space Flight activities to be funded in FY 2010 encompass completing construction of the International Space Station (ISS), retiring the Space Shuttle fleet upon completion of the ISS and delivery of the AMS to the ISS, stimulating development and demonstration of commercial space transportation vehicles that may support NASA's ISS cargo and potentially its crew requirements, and continuing the development of systems to deliver people and cargo to the ISS and the Moon and to explore other destinations. Along with the budget release, the Administration also announced the establishment of an independent review of NASA's human space flight activities. Results from that review will support a planned August 2009 decision on how the Nation's human space flight will proceed. OSTP Director John Holdren's May 7, 2009 letter to NASA's Acting Administrator and a recent communication to the Committee from NASA concerning the Human Space Flight Review are attached as Attachments 3 and 4 respectively.

Space Shuttle

NASA is requesting approximately $3.16 billion for the Space Shuttle Program, an increase of about $175 million over that enacted in FY 2009 and an increase of about $173 million from that projected for FY 2010 in last year's budget submission. Requested funding will enable the Agency to conduct an additional Shuttle mission to transport the Alpha Magnetic Spectrometer (AMS) per the direction of the *NASA Authorization Act of 2008* [P.L. 110–422]. Following return of the Hubble servicing mission currently underway, eight Space Shuttle flights will remain to be flown. NASA believes these flights can be accomplished by the end of 2010, after which the Shuttle fleet will be retired.

According to NASA, it has accounted for Shuttle transition and retirement costs in projected budgets for the Shuttle Program in FY 2011 ($383 million) and FY 2012 ($88 million). This is a significant reduction from the multi-billion dollar cost estimate projected by NASA two years ago.

International Space Station

NASA is requesting approximately $2.27 billion for the ISS, an increase of about $207 million over that enacted in FY 2009 and a decrease of about $10 million from that projected in last year's budget submission for FY 2010. Since the first component of the Station was put in orbit in November 1998, the ISS has grown into a fully functioning laboratory that will shortly house an increased crew size of six. The recent additions of the final set of solar arrays and a replacement Distillation Assembly for the water recycling system make this increased crew size possible. NASA plans to complete assembly of the ISS in 2010, including the additional research capability provided by the AMS.

NASA and its Russian, Japanese, European, and Canadian ISS partners are nearing completion of their goal of being able to conduct various types of research on

a Space Station in Earth orbit. Some of NASA's work is focused on increasing knowledge of the effects of long-duration human space flight, which is critical for the design and operation of future human space vehicles to return U.S. astronauts to the Moon and explore other destinations. Other non-exploration-related research is also being conducted, as described in the next section. At present, the U.S. has made no final decision on whether or not to operate and utilize the ISS after 2015; however, the international partners have indicated a desire to conduct research beyond that time. The question of whether to operate and utilize the ISS beyond 2015 will be addressed by the aforementioned Human Space Flight Review.

The ISS Cargo Crew Services budget request for FY 2010 is $628 million, an increase of about $323 million over that enacted for FY 2009. It is worth noting that the ISS Cargo Crew Services budget is projected to reach about $1.14 billion in FY 2012. This activity consists of International Partners and commercial purchases. NASA has contracted with Russia's Roskosmos to purchase cargo transportation through 2011 and crew transportation through the spring of 2012. NASA recently made awards to SpaceX and Orbital Sciences to provide cargo and return services beginning in 2011 under the Commercial Resupply Services contract.

International Space Station Utilization

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. To that end, NASA is conducting research on the effects of long-duration space flight on humans, as well as examining potential countermeasures. NASA is also using the ISS to demonstrate advanced communications networking. For example, NASA is testing Disruption Tolerant Networking (DTN) software, a "deep space communications network modeled on the Internet," according to a November 2008 press release issued by NASA and JPL. NASA is also using the ISS to experiment with Communication, Navigation and Networking re-Configurable Testbed (CoNNeCT), which will use software reprogrammable radios that can be used to support long-duration space exploration missions. In addition, the ISS is currently testing and demonstrating technologies critical for long-term exploration, such as various life support system technologies.

The International Space Station National Laboratory activity allows other federal agencies and commercial partners to utilize research capacity on the ISS. NASA has signed memoranda of understanding with the National Institutes of Health and the USDA Agricultural Research Service for their potential research utilization of the ISS. A commercial company has been conducting research on *Salmonella* that is directed at developing a *Salmonella* target vaccine. According to NASA, non-NASA partners will be required to pay for the transportation of their research experiments to and from the ISS.

The FY10 budget request for ISS research, which is bookkept in the Exploration Systems (ESMD) budget has been cut by about $20 million from the FY09 enacted budget and is projected to be relatively flat in the out years. The status of the research community and investigations that are ready to fly on the ISS will be an issue for any potential plans to increase the utilization of the ISS. Previous budget cuts to space life sciences and physical sciences research have drastically reduced the number of principal investigators working in these areas of research since FY 2004. In addition, the number of post-doctoral students, Ph.D., Master's and Bachelor of Science students has dropped precipitously since FY 2004.

In the near future, NASA expects to increase the ISS crew from three to six, which will increase the crew time available for research, according to NASA officials. In addition, following the planned retirement of the Space Shuttle, opportunities to ferry research supplies, hardware, and samples to and from the ISS will depend on the availability of commercial and international cargo resupply services.

Exploration Initiative

President Bush proposed an exploration initiative in 2004 that envisioned a broad program of human and robotic exploration of the solar system, including completion of the ISS, development of a new human space transportation system, a human landing on the Moon by 2020, and exploration of other solar system destinations. The Congress authorized the exploration initiative in the *NASA Authorization Act of 2005* (P.L. 109–155) and the *NASA Authorization Act of 2008* (P.L. 110–422).

The President's proposal for NASA's FY 2010 budget provides $3.96 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; 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. The funding requested for FY 2010 is an increase of about $58 million over that enacted for FY 2009 and is about $225 million greater than that projected for FY 2010 in last year's President's budget request.

According to NASA, its requested FY 2010 funding level of $3.50 billion for Constellation Systems, coupled with an enacted FY 2009 funding level of $3.43 billion, puts it in a position to achieve the projected Initial Operational Capability (IOC) date of March 2015 for the Orion/Ares I. The Orion crew exploration vehicle ($1.38 billion) and Ares I crew launch vehicle ($1.42 billion) form the bulk of the Constellation FY 2010 budget request. The FY 2010 budget request for the Ares V cargo launch vehicle ($25 million) and its run-out budget for FY 2011 through FY 2014 ($100 million total) is insufficient to initiate full scale development of the heavy-lift launch vehicle that is designed to support exploration missions beyond low-Earth orbit. In addition, the five-year budget plan contains no significant funding for the Altair lunar lander.

Cargo and Crew Transportation

Once the Shuttle fleet is retired, NASA will rely on a variety of sources to transport cargo and crew to the ISS. The Agency's Commercial Crew and Cargo Program, whose goal is to spur private industry to provide cost-effective cargo delivery to the ISS, requests about $39 million in FY 2010; with the infusion of Recovery Act funds, the FY 2009 enacted level was $303 million. Flight demonstrations to the ISS are being planned by SpaceX and Orbital Sciences for May 2010 and March 2011 respectively. The Crew and Cargo Program is administered by the Exploration Systems Mission Directorate under Constellation Systems. The demonstration program ends in 2011.

Human Space Flight Review

As part of the submission of its FY 2010 NASA budget request, OSTP Director John Holdren announced that the Obama Administration was asking Mr. Norman Augustine to chair an independent review of NASA's planned human space flight activities. The stated goal of the review is *"to ensure that the Nation is pursuing the best trajectory for the future of human space flight-one that is safe, innovative, affordable, and sustainable."* The panel is to report its results by August of this year. According to Dr. Holdren's May 7th letter to NASA's Acting Administrator:

> *"The review should aim, specifically, to identify and characterize a range of options that spans the reasonable possibilities for continuation of U.S. human space flight activities beyond retirement of the Space Shuttle. Results and supporting analysis should be provided to involved Administration agencies and offices in sufficient time to support an August 2009 decision on the way forward. The identification and characterization of options should be cognizant of-and should address the implications for-the following objectives: (1) expediting a new U.S. capability to support utilization of the International Space Station; (2) supporting missions to the Moon and other destinations beyond low-Earth orbit; (3) stimulating commercial space flight capabilities; and (4) fitting within the current budget profile for NASA exploration activities."*

Space Communications

The President's FY10 budget requests $496.6 million for Space Communications and Navigation, about $86 million less than the FY09 enacted budget. The budget reflects the fact that NASA has largely completed acquisitions to replenish aging Tracking and Data Relay Satellite System (TDRSS) spacecraft, which are used to support "tracking, data, voice, and video services to the International Space Station (ISS), Space and Earth science missions, as well as other government agency users."

The FY10 budget request includes plans for NASA's Space Communications and Navigation program to demonstrate optical communications, which provide higher data rates and involve lower weight, space, and power requirements on spacecraft. Optical communications will help enable more science data to be transmitted to Earth more efficiently. NASA is planning to use a lunar dust and atmosphere mission, anticipated to launch in 2012, to conduct the first optical communications demonstration.

The Deep Space Network (DSN) "consists of three facilities spaced approximately 120 degrees apart on the globe to enable continuous communications to spacecraft as the Earth rotates." The DSN is aging and the GAO has raised concerns about its fragility and continuing ability to service a mounting workload. NASA's FY10 budget does not include funds for an upgrade. NASA will construct a new 34-meter

beam waveguide antenna in Australia and maintain the existing DSN system while completing an analysis to support a plan for a new phased-array DSN system.

Education

The President's budget proposes $126.1 million in FY10 to support NASA's Education program. Although the proposed FY10 budget represents no change in the request for FY10 made in the previous budget plan, it reflects a reduction of about $43 million from the FY09 enacted budget.

The FY10 budget reflects some reorganization of education projects into three program areas:

- The Higher Ed STEM Education program includes the Minority University Research and Education Program (MUREP), Space Grant, and Experimental Program to Stimulate Competitive Research (EPSCoR).
- The K–12 STEM Education program is aimed at engaging and retaining students in STEM disciplines through flight opportunities, hands-on science and engineering activities, and the use of NASA content in teacher development resources.
- Informal STEM Education supports NASA Center activities that respond to requests from community and other informal education providers that use NASA content to engage participants in STEM activities. This program also supports museums, science centers, planetariums, and other venues that help ''the American public understand NASA's exploration mission.''

In addition to the programs included in NASA's Office of Education, the Science Mission Directorate, the Aeronautics Mission Directorate, the Exploration Systems Mission Directorate, and the Space Operations Mission Directorate as well as the NASA Centers all fund educational projects. How NASA is coordinating education among the Office of Education, the Centers, and the mission directorates on education activities and whether that coordination is effective are potential issues for the hearing.

Facilities and Maintenance

NASA's institutional investments are intended to ensure that facilities and field installations can meet the Agency's mission requirements in a safe, secure and environmentally sound manner. NASA is requesting $355.4 million in FY 2010 for institutional investments. Of that amount, about $284 million is for construction of facilities which provides for the construction, repair, rehabilitation, and modification of basic infrastructure and institutional facilities. Replacement and renewal projects replacing old, inefficient, and deteriorated buildings with energy efficient buildings will reduce utility usage. The remaining $71 million requested for FY 2010 is for environmental compliance and restoration which provides the personnel, services, and activities necessary to complete the cleanup of hazardous materials and wastes that have been released to the surface or groundwater at NASA installations. These activities are mandated under a variety of federal and State environmental laws and regulations, as well as legally enforceable orders and agreements.

NASA has recently undergone a comprehensive review of its facilities and is developing plans to reduce and renew these critical assets. It is worth noting that NASA's estimate of backlogged facilities and maintenance requirements totals $2 billion. So while projected budget requests for construction and facilities rise from FY 2011 ($326 million) to FY 2014 ($397.4 million), it is unlikely that such projected levels will appreciably reduce the backlog in the near future.

In the 2008 *NASA Authorization Act* (P.L. 110–422, Section 1022), the Committee had expressed concern over the need for adequate maintenance and upgrading of NASA's facilities In that legislation, the NASA Administrator was directed to determine and prioritize the maintenance and upgrade backlog at each of NASA's Centers and associated facilities and ''develop a strategy and budget plan to reduce that maintenance and upgrade backlog by 50 percent over the next five years.'' The Administrator is to deliver those reports to Congress concurrent with the delivery of the FY 2011 budget request.

Earth-Bound Applications of NASA-Developed Technologies

Technologies and devices developed by NASA to enable space missions and aeronautics research can provide societal benefits when transferred to terrestrial applications. For example:

- A resin developed by NASA for space applications was licensed to a medical technology company who in turn incorporated the material into its design for

a left-heart lead. The left-heart lead, which was recently approved by the Food and Drug Administration, delivers electrical impulses directly to the heart from a pacing device implanted in a patient's chest. The NASA-developed resin is highly flexible, resistant to chemicals, and can withstand extreme hot and cold temperatures. The "super plastic" is biologically inert, thus making it suitable for medical use, including implantable devices. The NASA-developed insulation material enabled the company to develop one of the thinnest left-heart leads available.

- An electronic nose developed for monitoring air quality on the International Space Station has shown promise as a new weapon against brain cancer. The electronic nose, developed by NASA to automatically monitor the station's air, is able to detect contaminants within a range of one to approximately 10,000 parts per million. In a series of experiments, researchers used NASA's device to "sniff" brain cancer cells and cells in other organs. Their data demonstrated that the electronic nose can sense differences in odor from normal versus cancerous cells. These experiments will help pave the way for more sophisticated biochemical analysis and experimentation.

Transfer of NASA technology to the private sector is performed by NASA's Innovative Partnerships Program. The agency's view is that advancing technology through partnerships enables it to address its own needs and apply NASA-derived technology to a range of applications that can provide broad benefit to the public. The program consists of three elements: Technology Infusion, Innovation Incubator, and Partnership Development. For FY 2010, NASA is requesting $184.8 million for the Innovative Partnerships program, an increase of about $25 million over that enacted in FY 2009 and an increase of about $3 million from that projected for FY 2010 in last year's budget submission.

Attachment 1

NASA's FY 2010 Budget Request

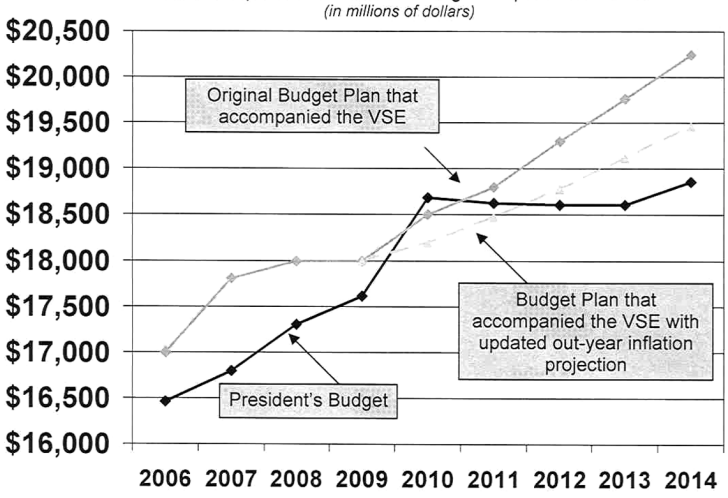
Budget Authority ($M)	FY 2008	FY 2009	Recovery Act	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Science	**4,733.2**	**4,503.0**	**400.0**	**4,477.2**	**4,747.4**	**4,890.9**	**5,069.0**	**5,185.4**
Earth Science	1,237.4	1,379.6	325.0	1,405.0	1,500.0	1,550.0	1,600.0	1,650.0
Planetary Science	1,312.6	1,325.6		1,346.2	1,500.6	1,577.7	1,600.0	1,633.2
Astrophysics	1,395.6	1,206.2	75.0	1,120.9	1,074.1	1,042.7	1,126.3	1,139.6
Heliophysics	787.6	591.6		605.0	672.6	720.5	742.7	762.6
Aeronautics	**511.4**	**500.0**	**150.0**	**507.0**	**514.0**	**521.0**	**529.0**	**536.0**
Exploration	**3,299.4**	**3,505.5**	**400.0**	**3963.1***	**6076.6***	**6028.5***	**5966.5***	**6195.3***
Constellation Systems	2,675.9	3,033.1	400.0	3,505.4	5,543.3	5,472.0	5,407.6	5,602.6
Advanced Capabilities	623.5	472.3		457.7	533.3	556.5	558.9	592.7
Space Operations	**5,427.2**	**5,764.7**	**0.0**	**6,175.6**	**3,663.8**	**3,485.3**	**3,318.6**	**3,154.8**
Space Shuttle	3,295.4	2,981.7		3,157.1	382.8	97.8	0.0	0.0
International Space Station	1,685.5	2,080.2		2,267.0	2,548.2	2,651.6	2,568.9	2,405.9
Space and Flight Support (SFS)	446.2	722.8		751.5	732.7	745.9	749.7	748.9
Education	**146.8**	**169.2**	**0.0**	**126.1**	**123.8**	**123.8**	**123.8**	**125.5**
Cross-Agency Support	**3,251.4**	**3,306.4**	**50.0**	**3,400.6**	**3,468.4**	**3,525.7**	**3,561.4**	**3,621.4**
Center Management and Operations	2,011.7	2,024.0		2,084.0	2,119.2	2,142.5	2,166.1	2,189.9
Agency Management and Operations	834.1	921.2		961.2	956.9	964.5	972.3	981.5
Institutional Investments	325.5	293.7	50.0	355.4	392.3	418.7	423.0	450.0
Congressionally Directed Items	80.0	67.5		0.0	0.0	0.0	0.0	0.0
Inspector General	**32.6**	**33.6**	**2.0**	**36.4**	**37.0**	**37.8**	**38.7**	**39.6**
NASA FY 2010	**17,401.9**	**17,782.4**	**1,002.0**	**18,686.0**	**18,631.0**	**18,613.0**	**18,607.0**	**18,858.0**
Year to Year Change		*2.2%*		*5.1%*	*-0.3%*	*-0.1%*	*0.0%*	*1.3%*

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

Attachment 2

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

(in millions of dollars)



Attachment 3

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20502

May 7, 2009

Christopher Scolese
NASA Acting Administrator
NASA Headquarters
Washington, DC 20546

Dear Chris,

The President believes strongly that space flight is important to America's economic, technological, and scientific leadership, and supports renewed human exploration to the Moon and other destinations beyond low Earth orbit. He fully understands that a strong and vibrant National Aeronautics and Space Administration can serve as a high-tech crucible for ingenuity, helping America maintain its innovative edge. And he appreciates that a robust human spaceflight program, in particular, can nourish the imagination, enrich an appreciation of our planetary home, and inspire the kind of bold achievements for which NASA and this nation have come to be known.

Given the magnitude of America's human space flight ambitions, however, and the significant investment of both funds and scientific capital that will be required to achieve the program's goals, it would be only prudent for the new Administration to review the array of challenges in the program and the options for addressing them as we move forward.

To this end, and in order for the United States to advance its goals and international leadership with regard to space exploration, I request that NASA initiate an independent review of ongoing U.S. human space flight plans and programs, as well as alternatives, to ensure that the nation is pursuing the best trajectory for the future of human space flight – one that is safe, innovative, affordable, and sustainable.

The review should aim, specifically, to identify and characterize a range of options that spans the reasonable possibilities for continuation of U.S. human space flight activities beyond retirement of the Space Shuttle. Results and supporting analysis should be provided to involved Administration agencies and offices in sufficient time to support an August 2009 decision on the way forward. The identification and characterization of options should be cognizant of – and should address the implications for – the following objectives: (1) expediting a new U.S. capability to support utilization of the International Space Station; (2) supporting missions to the Moon and other destinations beyond low Earth orbit; (3) stimulating commercial space flight capabilities; and (4) fitting within the current budget profile for NASA exploration activities.

This independent review should be led by a blue-ribbon panel of outside experts who would work closely with NASA. It should seek input from Congress, the White House the public, industry, and international partners. In addition to the objectives described above, the review should determine the appropriate amount of R&D and complementary

Enclosure 1

robotic activities needed to make human space-flight activities most productive and affordable over the long term, as well as appropriate opportunities for international collaboration. It should also evaluate what capabilities would be enabled by each of the potential architectures considered. And it should evaluate options for extending International Space Station operations beyond 2016.

While the study is ongoing, NASA should continue to work on all of its current exploration projects, including *Ares I*, *Orion*, Commercial Crew and Cargo efforts, and lunar systems.

For fifty years, NASA has thrilled and educated the world with its space exploration programs, while serving as a crucial home to scientific and technological innovation, enhancing America's leadership in Earth observation, and maintaining our national security. The results of this important review will help ensure that the agency continues to lead in these roles for decades to come.

Sincerely,

John Holdren

Director, Office of Science and Technology Policy
Assistant to the President for Science and Technology

VSE = Vision for Space Exploration

Attachment 4

National Aeronautics and Space Administration
Office of the Administrator
Washington, DC 20546-0001

May 11, 2009

The Honorable Bart Gordon
Chairman
Committee on Science and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The purpose of this letter is to notify the Committee that, at the request of the Director of the Office of Science and Technology Policy, NASA is initiating an independent review of planned U.S. human space flight activities, with the goal of ensuring that the Nation is on a vigorous and sustainable path to achieving its boldest aspirations in space. This review will be conducted by a blue-ribbon panel of outside experts chaired by Norman R. Augustine, supported by a NASA team led by Dr. W. Michael Hawes, Associate Administrator for Program Analysis and Evaluation. The panel will present its results in time to support an Administration decision on the way forward by August 2009.

This Review of U.S. Human Space Flight Plans will examine ongoing and planned NASA human space flight development activities, as well as potential alternatives, and present options for advancing a safe, innovative, sustainable, and affordable human space flight program in the years following completion of the current Space Shuttle manifest and retirement. Specifically, the review panel will consider:

- expediting a new U.S. capability to support use of the International Space Station (ISS);
- supporting missions to the Moon and other destinations beyond low Earth orbit;
- stimulating commercial space flight capabilities; and,
- fitting within the current budget profile for NASA exploration activities.

The independent review panel will seek input from Congress, the White House, the public, industry, and international partners. In addition to the objectives described above, the review will examine the appropriate amount of R&D and complementary robotic activities needed to make human space flight activities most productive and affordable over the long term, as well as appropriate opportunities for international collaboration. It will also evaluate what capabilities would be enabled by each of the potential architectures considered. And, it will evaluate options for extending ISS operations beyond 2016.

It is important to note that the President has submitted a FY 2010 budget request for NASA Exploration Systems of $3.963 billion, an increase of $457.6 million above the FY 2009 Omnibus Appropriations level. During the review, the NASA workforce will continue to focus on the safe flight and operation of the Space Shuttle and ISS and continue to work on all of its current exploration projects, including Ares I, Orion, and Commercial Crew and Cargo efforts.

The Committee to Review U.S. Human Space Flight Plans will be established and operate pursuant to the Federal Advisory Committee Act, as amended, 5, U.S.C. App. NASA's current estimate of resources required for the review is approximately $3 million. NASA will identify resources for the review within available FY 2009 Exploration Systems appropriations and Cross-Agency Support/Agency Management appropriations for independent assessments.

Enclosed, for your information, is a copy of the letter from Dr. John P. Holdren to NASA requesting initiation of the review and my letter in response. I would be pleased to discuss the establishment and objectives of the Review of U.S. Human Space Flight Plans with you in greater detail at your convenience.

Sincerely,

C. J. Scol

Christopher J. Scolese
Acting Administrator

2 Enclosures

Chairman GORDON. This hearing will come to order, and good afternoon, and welcome. Mr. Scolese, we are glad you are here, and Mr. Hall is here, too. We are—just to let everyone know, at 2:30 or hopefully more of a quarter until votes will start on the Floor we are told, and there will be a series of them, so it goes for awhile, and so what we are hoping to do is be able to have a good hearing here before so we don't hold everybody up. And Mr. Hall concurs, and we are glad of that.

So before I go any further I would just like to take a moment and express my appreciation for your service over these past few months. You were handed a very challenging job when you were asked to serve as our Acting Administrator for NASA, and by all accounts you have handled your responsibility with distinction as you have done your previous jobs there. It is a clear reflection of your competence and skill, but it is also I think an indication of the high caliber of civil service employees at NASA.

And so we have seen the competence on display over the past few days as a crew of seven NASA astronauts has worked to service the Hubble Space Telescope to the extent its ability to conduct productive science. At the same time three crew members are operating overhead in the International Space Station with their own set of complex tasks to carry out, and we have seen multiple examples of the value of NASA science research that has helped us to better understand both climate change here on Earth and events in the far reaches of the universe.

And we have seen NASA-funded aeronautics R&D transform the Nation's commercial and military aviation capabilities over the past five decades, yet it has become clear in recent years that resources given to NASA haven't kept pace with the tasks that the Nation has asked it to carry out.

That is why this committee and ultimately Congress as a whole passed the *NASA Authorization Act of 2008,* which authorized a significant increase in funding for NASA, and I am very pleased that the Obama Administration has responded to that Congressional consensus by supporting augmented funding for NASA in both the Recovery Act and the fiscal year 2010, budgetary request.

It is a welcome recognition that NASA is relevant to address the Nation's societal needs and is an important contributor to our scientific and technical competitiveness. That is good news.

However, more needs to be done if the positive steps taken by this Administration are going to be sustained. For example, it is clear that the flat-funded proposal for NASA after fiscal year 2010 would make it very difficult to make progress on a number of important programs, including the Exploration Initiative that was endorsed by Congress in the last two NASA Authorizations Acts.

And while I hope and expect that the human space flight review that is going to be conducted under the very able leadership of Norm Augustine will help clarify what is needed to keep that important initiative on track, I think the basic situation is already clear. Either the Nation is going to have to give NASA enough funding to meet the dual challenges of carrying out its current and planned missions and of revitalizing the Agency's human and physical capital, or the Nation is going to have to agree on what it wants NASA to cut.

As the overwhelming bipartisan support of—for the *NASA Authorization Act of 2008* demonstrates, Congress believes that NASA is an important contributor to America's future, well-being, and worthy of our increased investment in it. At the same time I don't view investing in NASA as a blank check. This committee is going to be vigilant in seeking to ensure that NASA is a good steward of taxpayer dollars.

Indeed, the first hearing of Chairman Giffords' Space and Aeronautics Subcommittee earlier this year was on NASA's cost management practices, and I have no doubt the Committee will continue our oversight on these issues in the months ahead.

So we are going to go forward with the Reauthorization of NASA this year, and we need to have a good understanding of the issues and opportunities facing the Agency in the wake of the President's budget request. Today's hearing is the first step in that progress—in that process, and I, again, want to welcome Acting Administrator Scolese for your participation and look forward to your testimony.

And now I recognize Mr. Hall for an opening statement.

[The prepared statement of Chairman Gordon follows:]

PREPARED STATEMENT OF CHAIRMAN BART GORDON

Good afternoon, and welcome Mr. Scolese.

Before I go any further, I'd just like to take a moment to express my appreciation for your service over these past several months.

You were handed a very challenging job when you were asked to serve as Acting Administrator of NASA, and by all accounts you have handled your responsibilities with distinction.

That's clearly a reflection on your competence and skill.

But it's also an indication of the high caliber of the civil service employees we have at NASA, of which you are one.

We've seen that competence on display over the past few days as a crew of seven NASA astronauts has worked to service the Hubble Space Telescope to extend its ability to conduct productive science.

At the same time, three crew members are orbiting overhead in the International Space Station, with their own set of complex tasks to carry out.

We're seeing multiple examples of the value of NASA scientific research that has helped us better understand both climate change here on Earth and events in the far reaches of the universe.

And we've seen NASA-funded aeronautics R&D transform the Nation's commercial and military aviation capabilities over the past five decades.

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That's good news.

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what is needed to keep that important initiative on track, I think the basic situation is already clear.

Either the Nation is going to have to give NASA enough funding to meet the dual challenges of carrying out its current and planned missions and of revitalizing the Agency's human and physical capital . . ..

Or, the Nation is going to have to agree on what it wants NASA to cut.

As the overwhelming bipartisan support for the *NASA Authorization Act of 2008* demonstrated, Congress believes that NASA is an important contributor to America's future well-being, and worthy of our increased investment in it.

At the same time, I don't view investing in NASA as a blank check—this committee is going to be vigilant in seeking to ensure that NASA is a good steward of taxpayer dollars.

Indeed, the first hearing of Chairwoman Giffords' Space and Aeronautics Subcommittee earlier this year was on NASA's cost management practices, and I have no doubt the Committee will continue our oversight of those issues in the months ahead.

We are going to be reauthorizing NASA this year, and we need to have a good understanding of the issues and opportunities facing the Agency in the wake of the President's budget request.

Today's hearing is the first step in that process, and I again want to welcome Acting Administrator Scolese's participation.

We look forward to your testimony.

Mr. HALL. Mr. Chairman, in the interest of time I will not present my entire statement. I ask unanimous consent that it be put in the record.

I just want to thank you. You have pretty well—you have very well covered the opening statements for both of us, but I want to thank you for holding this hearing. And 2010, as you know and we all realize, is a very pivotal year for our Space Program, and this is a very important opportunity to hear from NASA and seek answers to a lot of questions.

I would like to also welcome our witness, Acting NASA Administrator. Chris, thank you. You have been doing a difficult job under challenging circumstances, and thank you for your dedication.

I will skip on over and just say NASA is one area of the federal budget where I think some increases are justified. Three percent sounds like a lot to a lot of people, but that is a very small budget for anything as important as NASA is to this country. We may just defend the next war out of space. We have got to be ready for those things, and NASA is so very important to us. The Administration has called for an independent review of human space flight to be chaired by Norm Augustine, and the President couldn't have picked a better person for that, a more knowledgeable person for it. I had a visit with him this morning, and I am sure that he visited the Chairman before he came to my office, but he is a great American and outstanding person to make that study for you, and let me tell you, he will call it like it is, and he will call it like he sees it. So we are very lucky to have him doing that.

And NASA is still on the path to complete the remaining Shuttle missions, including an additional flight to deliver the Alpha-Magnetic Spectrometer. Hell, I can't say anything. And then retire the Shuttle without having developed a new capability to get independently to and from the ISS. That is one of the major problems, and we are hoping that Norm is going to give us some answers to that.

And I am very concerned that the budget has deleted nearly all of the out-year funding for the lunar landing, and for the heavy-lift Constellation launch vehicle that is necessary to get us out of the lower orbit. The Exploration Program needs stability in growth

and can't be—has to be properly funded, which I don't think they are.

I just close by saying American companies have until recently led the world in the production of leading-edge technology and aviation communications, surveillance and navigation services. I am aware that under-investing in these disciplines are going to be—and I don't know how many years to say, but really come home to haunt us. We are making a mistake. I hope you can lead us out of that mistake.

Look forward to hearing you. Thank you, Mr. Chairman. I yield back.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF REPRESENTATIVE RALPH M. HALL

Mr. Chairman, I want to thank you for holding this hearing on *NASA's Fiscal Year 2010 Budget Request*. 2010 is a pivotal year for our space program, and this is an important opportunity to hear from NASA and seek answers to a wide-range of questions.

I would also like to welcome our witness, Acting NASA Administrator Chris Scolese who has been doing a difficult job under challenging circumstances. Thank you for your dedication and commitment.

NASA gives our country so much to be proud of. Right now, 350 miles up, Shuttle astronauts are wrapping up an extraordinary mission. They salvaged a multi-billion dollar Space Science mission by repairing the Hubble Space Telescope during a series of complicated and dangerous spacewalks. This mission showcases the unique capabilities of the Space Shuttle which will be lost after it is retired. This is a very daring mission, and the men and women we send into space put their lives on the line. They deserve our support, and they deserve the best equipment and training we can provide.

NASA is one area of the federal budget where I think some increases are justified. While we do not need to add more money to the ballooning deficit, we should prioritize federal spending on programs that yield great returns—and NASA is one of those programs. I am encouraged that NASA's FY 2010 budget request of $18.7 billion is about five percent above last year's appropriation, but as I said to Dr. Holdren last week, I am very concerned that priorities may be shifting away from human space exploration at a very critical time. The Administration has called for an independent review of Human Space Flight to be chaired by Norm Augustine that is expected to make recommendations later this summer. There are many questions that should be answered including about whether to extend the International Space Station beyond 2016. The ISS is a valuable National Laboratory and we should be seeking new and innovative research to perform there well into the future.

NASA is still on a path to complete the remaining Shuttle missions, including an additional flight to deliver the Alpha-Magnetic Spectrometer (AMS) to the ISS, and then retire the Shuttle without having developed a new capability to get independently to and from the ISS. In the resulting gap we stand to lose a highly skilled workforce and a number of accompanying parts suppliers and other contractors that we cannot afford to lose—as we did between Apollo and Shuttle.

Mr. Chairman, I am also very concerned that this budget has deleted nearly all the out-year funding for the Lunar Lander and for the heavy-lift Constellation launch vehicle that is necessary to get us out of low-Earth orbit. The Exploration program needs stability and growth and cannot be the bill-payer for the rest of the Agency.

Moreover, NASA's science and aeronautics programs, like the Agency's top line, show little growth, with the exception of Earth Science and Heliophysics. Just like human space flight, these important research programs are financially stressed, experiencing cost growth that far exceed increases in their respective budget lines. We are at risk of launching fewer and fewer research missions, and I am concerned we will lose the research infrastructure that has been so important to NASA, but is also a source of important new technologies for American commerce, especially for our satellite and aerospace industries. American companies have, until recently, led the world in the production of leading-edge technologies in aviation, communications, surveillance, and navigation services. I worry that under-investing in these disciplines will—in 10 to 15 years time—really come back to haunt us.

Mr. Chairman, we have a lot of issues to discuss today. I look forward to a productive hearing.

Chairman GORDON. Thank you, Mr. Hall. I certainly concur with your comments.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good Morning. Thank you, Mr. Chairman, for holding today's hearing on the *NASA Fiscal Year 2010 (FY10) Budget Request.*

NASA has requested $18.7 billion in funding for FY10, an increase of 5.1 percent over Fiscal Year 2009 (FY09). I am pleased to see that the FY10 budget request continues to address the budget shortfalls NASA saw during the previous Administration and to make steps towards fulfilling the *Vision for Space Exploration* introduced by President Bush in 2004. However, the budget projects relatively flat funding through Fiscal Year 2013, which may negatively impact NASA's ability to fulfill its complex, important, and broad-ranging mission. I look forward to discussing how NASA can continue to fulfill its mission under this projected budget.

I have three specific concerns about the NASA budget request for FY10. First, as a strong supporter of STEM education, I was concerned to see a $43 million reduction in funding for STEM programs. I support NASA's decisions to reorganize and streamline STEM education projects into three program areas, and I am pleased to see that NASA will continue to contribute to STEM projects at every level of education. However, I believe these programs need more financial support than requested in the FY10 budget. I would like to hear from Administrator Scolese how this committee can work with NASA to ensure that this decrease in funding does not impact access to STEM education for American students.

Second, as the Chairman of the Aviation Subcommittee, I am pleased to see that NASA will continue to invest in aeronautics research, particularly the Next Generation Air Transportation System (NextGen). In particular, I support NASA's decision to redesign its research efforts and distinguish between technology development and research on integration and evaluation. However, the FY10 budget proposes a $143 million decrease in funding for NASA's work on NextGen. I do not support reducing this funding, in particular because NASA contributes vital research on aviation safety and environmental impact to the program. I would like to hear from Administrator Scolese how the decrease in the Aeronautics budget will impact NASA's role in NextGen.

Third, I am concerned about the continued cost growth and schedule delays that plague NASA projects. NASA remains on the GAO watch list for agencies at a high risk for contract management, and despite efforts to improve the budget process within the Agency, an independent auditor could not come to any conclusion on the Agency's financial statements because of serious problems in its financial reporting. These problems make NASA inefficient, and as we discussed in an Energy and Environment Subcommittee hearing last month these continued delays and cost increases limit the Agency's ability to update technology and remain on the cutting edge of space exploration and research. I would like to hear from Administrator Scolese what long-term and short-term strategies NASA has in place to address these problems.

I welcome Administrator Scolese, and I look forward to his testimony.

Thank you again, Mr. Chairman.

[The prepared statement of Mr. Mitchell follows:]

PREPARED STATEMENT OF REPRESENTATIVE HARRY E. MITCHELL

Thank you, Mr. Chairman.

Today we will discuss *NASA's Fiscal Year 2010 Budget Request,* NASA's proposed Fiscal Year 2009 Operating Plan, and use of funds through the *American Recovery and Reinvestment Act.*

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 work 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.

I look forward to hearing more from our witnesses.

I yield back.

Chairman GORDON. Where we are is that the votes have started earlier than we thought, so Mr. Scolese, I think the thing to do is for you to go forward, make your statement, and then we will try to make you comfortable here while we go vote and come back as quickly as we can.

And so let me now call upon our witness today, Mr. Christopher Scolese, who is the Acting Administrator, as well as the Associate Administrator, of the National Aeronautics and Space Administration.

And you are recognized for five minutes or the time you may consume.

STATEMENT OF MR. CHRISTOPHER J. SCOLESE, ACTING ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Mr. SCOLESE. Okay. Thank you, sir. Chairman Gordon, Ranking Member Hall, and Members of the Committee, thank you for inviting me here today to discuss the President's fiscal year 2010 budget request for NASA. The President's request of $18.686 billion for NASA represents an increase of $903.6 million above the fiscal year 2009 Omnibus Appropriation.

First, let me note that NASA's fiscal year 2009 budget is $18.784 billion or about $1.17 billion above the fiscal year 2009 request, which reflects and increase of $168.2 million in the regular appropriation and about $1 billion in the Recovery Act. NASA is appreciative of the support of this committee and Congress for the *NASA Authorization Act of 2008* full funding of the fiscal year 2009 request, and for the additional Recovery Act funds which will enable NASA to meet critical priorities.

The President's fiscal year 2010 request includes $4.5 billion for science. In Earth science, NASA is continuing to work aggressively to implement the recommendations of the Decadal Survey. The first four Decadal missions will be accelerated, and NASA will issue its first venture class announcement of opportunity later this year.

Over the next year we plan to launch the Glory and Aquarius missions and the GOES–R mission for NOAA and complete the NPOESS Preparatory Project. Further, we will continue development of the foundational missions, including the Global Precipitation Mission, the Landsat Data Continuity Mission, and initiate work on the Thermal Infrared Sensor. NASA is further assessing options to recover from the disappointing loss of the Orbiting Carbon Observatory and will keep you informed of our findings and plans.

In planetary science, we are continuing the exploration of the solar system with the Juno Mission to Jupiter and the Mars Science Laboratory and the MAVEN Scout Mission.

In astrophysics, I am pleased to report that the final Hubble Servicing Mission, EBA, was completed yesterday, and this morning the Space Shuttle successfully released a revitalized Hubble Space Telescope. We look forward to the safe return of the crew and to many more years of discovery from Hubble.

Development continues on the James Webb Space Telescope, which passed its confirmation review in 2008, and has an agency commitment to launch in 2014. NASA's fleet of Heliophysics Missions strategically placed throughout the solar system is providing researchers the first ever solar system-wide view of solar influences on Earth and other planets. The fiscal year 2010 request of $507 million renews NASA's commitment to a strong national program in aeronautics that will continue to contribute to the economic wellbeing and quality of American—of life of American citizens through strong partnerships with industry, academia, and government.

In exploration, the President's fiscal year 2010 budget request is $3.963 billion, an increase of $457.6 million above the fiscal year 2009 Omnibus Appropriations level and $225.4 million above last year's plan. This increased budget will support continued progress in NASA's efforts to advance the development of the Next Generation Human Space Flight System to carry American crews and supplies to space and work to return Americans to the Moon.

Specifically, the Lunar Reconnaissance Orbiter and the Lunar Crater Observation Sensing Satellite Spacecraft are ready for launch next month. Later this year, two major test flights will be conducted; the Ares I–X developmental test flight from Kennedy Space Center and the Orion Pad Abort 1 test at White Sands.

At the request of the director of the Office of Science and Technology Policy, NASA is initiating an independent review of U.S. human space flight plans to be conducted by a blue ribbon panel of outside experts chaired by Norm Augustine. The review will examine ongoing and planned NASA human space flight development activities, as well as potential alternatives and present options for advancing safe, innovative, sustainable, and affordable human space flight program in the years following the retirement of the Space Shuttle. It will also evaluate options for extending the life of the ISS beyond 2016 and present its results by August, 2009.

During the review, the NASA workforce will continue to work on all current exploration projects including Ares I. The President's budget request includes $6.176 billion for space operations, which funds safe flight of the Space Shuttle to complete the eight remaining scheduled flights to the ISS and then retire the Shuttle. We believe these flights can be accomplished by the end of 2010.

This month ISS will host its first six-person crew and next month will deliver the third and final component of the Japanese Kibo Laboratory. Last December, NASA awarded two commercial re-supply services contracts to develop vehicles needed to deliver supplies and experiments to the ISS.

Finally, the 2010 request supports NASA's education program to continue developing a future aerospace technical and scientific workforce, improving the technological competitiveness of our nation's universities and attracting and retaining students in science, technology, engineering, and mathematics disciplines. This request also funds NASA's cross-agency support programs, which provide critical mission support activities necessary to ensure the efficient and effective operation and administration of the Agency and its centers.

Chairman Gordon, thank you again for your support and that of this committee. I would be pleased to respond to any questions that you may have.

[The prepared statement of Mr. Scolese follows:]

PREPARED STATEMENT OF CHRISTOPHER J. SCOLESE

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear today to discuss the President's FY 2010 budget request for NASA. The President's FY 2010 budget request for NASA is $18.686 billion. The FY 2010 request represents an increase of $903.6 million above the amount provided for NASA in the FY 2009 *Omnibus Appropriations Act* (P.L. 110–8). The FY 2010 budget does a number of things: it supports the Administration's commitment to deploy a global climate change research and monitoring system; it funds a strong program of space exploration involving humans and robots with the goal of returning Americans to the Moon and exploring other destinations; and it supports the safe flight of the Space Shuttle to complete assembly of the International Space Station by the Space Shuttle's planned retirement.

Highlights of the FY 2010 Budget Overview

With the FY 2010 budget request, NASA advances global climate change research and monitoring. The NASA investment in Earth science research satellites, airborne sensors, computer models and analysis has revolutionized scientific knowledge and predictions of climate change and its effects. Using the National Research Council's recommended priorities for space-based Earth science research as its guide, NASA will develop new space-based research sensors in support of the Administration's goal to deploy a global climate research and monitoring system. NASA will work to deploy these new sensors expeditiously while coordinating with other federal agencies to ensure continuity of measurements that have long-term research and applications benefits.

The FY 2010 NASA request funds a robust program of space exploration involving humans and robots. NASA's astronauts and robotic spacecraft have been exploring our solar system and the universe for more than 50 years. The Agency will create a new chapter of this legacy as it works to return Americans to the Moon by 2020. NASA also will send a broad suite of robotic missions to destinations throughout the solar system and develop a bold new set of astronomical observatories to probe the mysteries of the universe, increasing investment in research, data analysis, and technology development in support of these goals.

With the FY 2010 request, NASA will complete the International Space Station (ISS) and advance the development of new space transportation systems and the unique scientific research that can be conducted on-board the ISS. The FY 2010 budget request funds for the safe flight of the Space Shuttle to complete the ISS, incorporates an additional flight to deliver the Alpha Magnetic Spectrometer (AMS) to the ISS, and then retires the Shuttle. NASA is committed to completing these nine remaining scheduled Shuttle flights, including the current mission underway to service the Hubble Space Telescope, which we believe can be accomplished by the end of 2010. Funds freed from the Shuttle's retirement will enable the Agency to support development of systems to deliver people and cargo to the ISS and the Moon and explore other destinations. As part of this effort, NASA will stimulate private-sector development and demonstration of vehicles that may support the Agency's human crew and cargo requirements for ISS. In addition, the Agency will continue to utilize the ISS, the permanently crewed facility orbiting Earth that enables the Agency to develop, test, and validate critical space exploration technologies and processes, and to conduct microgravity research. NASA also will continue to coordinate with international partners to make this platform available for other government entities, commercial industry, and academic institutions to conduct research.

At the request of the Director of the Office of Science and Technology Policy, NASA is initiating an independent review of planned U.S. human space flight activities, with the goal of ensuring that the Nation is on a vigorous and sustainable path to achieving its boldest aspirations in space. This review will be conducted by a blue-ribbon panel of outside experts chaired by Norman R. Augustine. The panel will present its results in time to support an Administration decision on the way forward by August 2009. This Review of U.S. Human Space Flight Plans will examine ongoing and planned NASA human space flight development activities, as well as potential alternatives, and present options for advancing a safe, innovative, affordable, and sustainable human space flight program in the years following completion of the current Space Shuttle manifest and retirement. The independent review

panel will seek input from Congress, the White House, the public, industry, and international partners. In addition, the review will examine the appropriate amount of R&D and complementary robotic activities needed to make human space flight activities most productive and affordable over the long-term, as well as appropriate opportunities for international collaboration. It will also evaluate what capabilities would be enabled by each of the potential architectures considered. And it will evaluate options for extending International Space Station operations beyond 2016. We will keep the Congress informed, as appropriate, with the progress of the review.

It is important to note that the President has submitted a FY 2010 budget request for NASA Exploration Systems of $3.963 billion, an increase of $457.6 million above the FY 2009 Omnibus Appropriations level. During the review, the NASA workforce will continue to focus on the safe flight and operation of the Space Shuttle and ISS, and continue to work on all current exploration projects, including Ares I, Orion, and Commercial Crew and Cargo efforts.

The President's FY 2010 budget request includes $507 million for Aeronautics Research, renewing NASA's commitment to cutting-edge, fundamental research in traditional and emerging disciplines to help transform the Nation's air transportation system and to support future aircraft. NASA research will increase airspace capacity and mobility, enhance aviation safety, and improve aircraft performance while reducing noise, emissions, and fuel consumption. The Integrated Systems Research Program, a new program beginning in FY 2010, will conduct research at an integrated system-level on promising concepts and technologies and explore, assess, and demonstrate the benefits in a relevant environment.

Finally, consistent with Administration priorities, NASA is developing plans to stimulate innovation and increase investments in technologies for the future while ensuring that nearer-term Agency commitments are met.

NASA Initial FY 2009 Operating Plan and Recovery Act Funding

Before I highlight key accomplishments and plans for activities across the Agency, I would like to summarize NASA's initial FY 2009 Operating Plan, including Recovery Act funding, as recently submitted to the Committee. The initial FY 2009 Operating Plan is $18,784.4 million, or $1,170.2 million above the President's FY 2009 request, which reflects an increase of $168.2 million in the regular appropriation and $1,002.0 million in the Recovery Act. NASA is appreciative of the action by the Committees on Appropriations and Congress in providing regular appropriations for the Agency with full funding for Science, Aeronautics, Exploration, Space Shuttle, ISS, and Education. This total FY 2009 appropriations level, with minor adjustments within the total, will enable NASA to meet critical priorities, in accordance with the direction from the Congress and the President. NASA also appreciates the efforts by the Committees to include funding for NASA in the Recovery Act. This funding will help NASA achieve programmatic goals in Science, Exploration and Aeronautics, and repair damage done to the NASA Johnson Space Center during Hurricane Ike, and support national recovery goals.

NASA has allocated the $1,002.0 million in Recovery Act funds as follows:

- Science, $400.0M
  - Earth Science, $325.0M
  - Astrophysics, $75.0M
- Aeronautics, $150.0M
- Exploration, $400.0M
  - Constellation Systems, $250.0M
  - Commercial Crew & Cargo, $150.0M
- Cross Agency Support, $50.0M
- Inspector General, $2.0M

I would be happy to address the objectives to which NASA is applying the Recovery Act funds in detail.

Science

NASA's Science Mission Directorate continues to expand humanity's understanding of our Earth, our Sun, the solar system and the universe with 57 science missions in operation and 31 more in development. The Science budget funds these missions as well as the research of over 3,000 scientists and their students across

the Nation. The President's FY 2010 request for NASA includes $4,477.2 million for Science.

The Science budget request includes $1,405.0 million for **Earth Science** in FY 2010, and steadily increases Earth science funding in the outyears. NASA's 15 Earth Science missions in operation provide a large share of the global observations used for climate change research in the United States and elsewhere. This year, NASA's Earth Science satellites enabled research to understand how changes both in the tropics and in Arctic sea ice are changing ocean biology globally. NASA also recently conducted the first Ice Bridge aircraft campaign to demonstrate a new airborne laser capability to bridge the gap in time between ICESats 1 and 2. In FY 2010, NASA plans to launch the Glory mission to map atmospheric aerosols and continue the long record of solar influences on climate, and the Aquarius mission to provide the first global measurements of sea surface salinity. NASA will complete development of the NPOESS Preparatory Project and continue development of the Global Precipitation Mission and the Landsat Data Continuity Mission (LDCM). The request fully funds development of a Thermal Infra-red Sensor (TIRS) at a total cost of approximately $150–175 million. A decision whether to fly TIRS on LDCM or another spacecraft will be made this summer; meanwhile, funding for TIRS is carried within the LDCM budget. The launch vehicle failure of the Orbiting Carbon Observatory (OCO) was a significant loss to the climate science communities, and NASA is assessing options to recover from that loss; we will inform the Congress of the results of these studies when they become available. NASA is continuing to work aggressively to implement the recommendations of the National Research Council Decadal Survey for Earth Science. The first two Decadal Survey missions, SMAP and ICESat-II, will continue formulation in FY 2010, and the next two, DESDynI and CLARREO, will be accelerated and transition to formulation. NASA also expects to issue its first Venture-class Announcement of Opportunity later this year, implementing another important decadal survey recommendation.

The FY 2010 Science budget request includes $1,346.2 million for **Planetary Science.** NASA's Planetary Science missions continue to return images and data from the far reaches of the Solar System. This year, the Mars Phoenix Lander completed its mission, conducting the first chemical test providing evidence of water ice on another planet. MESSENGER returned stunning imagery of portions of the planet Mercury never before seen. The Cassini spacecraft continues to provide un-paralleled science of the Saturnian system; the spacecraft flew within 25km of Enceladus viewing the ejecting plumes and surface, and data from 19 fly-bys of Titan enabled creation of a radar map showing 3–D topography revealing 1,200-meter (4,000-foot) mountain tops, polar lakes, vast dunes, and thick flows from possible ice volcanoes. Development is continuing on the Juno mission to Jupiter for launch in 2011. NASA and ESA jointly announced they will work together on a Europa Jupiter System mission as the next outer planets flagship mission. The rovers Spirit and Opportunity continue to study the Martian surface and have exceeded their fifth year of successful operations. NASA is continuing development of the Mars Science Laboratory (MSL) for launch in 2011 and selected MAVEN, a Mars aeronomy mission, as the next Mars Scout mission for launch in 2013. NASA has integrated its lunar science research program with the Lunar Precursor Robotic Program into a single Lunar Quest Program under the Science Mission Directorate, which includes the LADEE mission, the U.S. nodes of the ILN, and a new virtual university research collaboration called the NASA Lunar Science Institute. The Moon Mineralogy Mapper (M3) was launched aboard Chandrayaan-1 and has begun making scientific observations of the Moon's composition. Development is continuing on the GRAIL mission to map the Moon's gravity field for launch in 2011. NASA has issued an Announcements of Opportunity for the next New Frontiers mission, and will do so for the next Discovery mission later this year.

The FY 2010 Science budget request includes $1,120.9 million for **Astrophysics.** 2009 is the International Year of Astronomy, and NASA's Astrophysics program will deploy exciting new capabilities for studying the cosmic frontier. The Kepler mission, launched in March, is NASA's first mission dedicated to the search for Earth-like planets in our galaxy. ESA will launch the Herschel and Planck missions in April, carrying several NASA instruments, to study the far-infrared sky and the cosmic microwave background. The final Hubble Space Telescope serving mission aboard STS–125, currently in progress, is upgrading the observatory to its peak scientific performance. Late this calendar year, NASA plans to launch the Wide-field Infrared Survey Explorer (WISE) as part of its highly successful Explorer Program, following on the recent successes of the Fermi Gamma-ray Space Telescope (launched as GLAST in July 2008), which has provided the best-ever view of the gamma-ray sky revealing energetic sources in our solar system, our galaxy, and galaxies billions of light-years away. Development is continuing on the James Webb

Space Telescope, which passed its Confirmation Review in 2008 and has an Agency commitment to launch in 2014. Development continues on the NuSTAR mission to study black holes for launch in 2011, along with a Soft X-ray Spectrometer to fly on Japan's Astro-H mission in 2013. Development continues on the airborne Stratospheric Observatory for Infrared Astronomy or SOFIA, which will conduct open door flight tests in 2009 and early science flights in 2010, with planned full operational capability in 2014. Conceptual design is continuing for ambitious future mission concepts to investigate the origins of planets, stars, and galaxies; to search for Earth-like planets around nearby stars; and to examine the nature of dark energy, dark matter, gravity waves, and black holes. These and other mission concepts are currently under consideration by the NRC's decadal survey for Astrophysics, or Astro2010, which will be completed during 2010, and will provide recommendations to NASA on the science community's highest priority science questions and strategic missions for the next decade.

The FY 2010 Science budget request includes $605.0 million for **Heliophysics.** The fleet of NASA Heliophysics missions strategically placed throughout the solar system is providing researchers the first ever solar system-wide view of solar influences on the Earth and other planets, and the dynamic structures of space itself. This virtual "Great Observatory" is in place and functioning for the next solar magnetic activity cycle, and has already detected the first signs of a new solar maximum anticipated for 2011–2012. Late this year or early next, the launch of Solar Dynamics Observatory will add to this fleet the capability to observe the solar atmosphere to a depth one-third of the Sun's radius to study the flow of plasmas that generate magnetic fields and the sudden changes that produce coronal mass ejections that we experience as space weather. Also this year, NASA plans to select two Small Explorer (SMEX) missions in response to an Announcement of Opportunity issued in 2008, which could be either Heliophysics or Astrophysics missions depending on the proposals selected. Development of the Radiation Belt Storm Probes mission to study the interactions of space weather events with Earth's magnetic field is continuing for launch in 2012. The Magnetosphere Multi-Scale mission to observe the processes of magnetic reconnection, energetic particle acceleration, and turbulence in Earth's magnetosphere will undergo a Confirmation Review this year for a planned launch in 2014. Finally, NASA is continuing early formulation work on the Solar Probe-Plus mission that will travel into, and sample, the near-Sun environment to probe the origins of the solar wind.

Aeronautics Research

NASA's FY 2010 budget provides $507 million for Aeronautics Research. Over the past year, the Aeronautics Research Mission Directorate has continued to pursue long-term, 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. NASA Aeronautics Research also plays a vital role in supporting NASA's space exploration activities.

A primary goal across Aeronautics Research programs 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 (SAAs) 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. To date, 68 SAAs have been established with industry partners across all programs and 375 NRAs have been awarded to academia, industry and non-profit organizations. NASA Aeronautics has continued to collaborate with the Joint Planning Development Office (JPDO), Federal Aviation Administration (FAA), U.S. Air Force, Army, and other government organizations.

New for FY 2010, $62.4 million has been provided for the **Integrated Systems Research Program** (ISRP) to conduct research at an integrated system-level on promising concepts and technologies and explore, assess, or demonstrate the benefits in a relevant environment. The research in this program will be coordinated with on-going, long-term, foundational research within the three other research programs, and will be closely coordinated with other Federal Government agency efforts. The project within ISRP will be the Environmentally Responsible Aviation (ERA) Project, a "green aircraft initiative," that will explore and assess new vehicle concepts and enabling technologies through system-level experimentation to simultaneously reduce fuel burn, noise, and emissions. The ERA project will transfer knowledge outward to the aeronautics community so that aircraft and propulsion system manufacturers can confidently transition these technologies into new prod-

ucts, as well as transfer knowledge inward to the Fundamental Aeronautics Program when the need for further development at a foundational level is identified.

NASA's **Airspace Systems** Program (ASP) 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. For FY 2010, ASP has been reorganized from the NextGen Airspace and NextGen Airportal projects into the NextGen Concepts and Technology Development project and the NextGen Systems Analysis, Integration and Evaluation project. The distinctions between airport operations, terminal-area operations and en-route operations were sometimes confusing, leading to time expended determining the line of demarcation between the responsibilities of the two projects. A more significant distinction is the development of air traffic management concepts and the technologies that enable air traffic management improvements and the evaluation of these concepts and technologies at a system level. The previously planned work on airspace concepts, technologies and systems will continue. This new project structure is better aligned to the nature of the work being performed. A notable accomplishment for ASP is the successful completion, by NASA researchers in collaboration with academia and the FAA, of a series of human-in-the-loop experiments that explored advanced concepts and technology for separation assurance, which ensures that aircraft maintain a safe distance from other aircraft, terrain, obstacles, and certain airspace not designated for routine air travel. The technology being developed by NASA and its partners is critical to relieving air-traffic controller workload, a primary constraint on airspace capacity that is expected to increase in coming years. In the future, this Program will continue to develop new technologies to solve important problems such as surface traffic planning and control, and initial algorithms for airport arrival and departure balancing as well as developing traffic flow management concepts for increased efficiencies at the regional and national levels for different planning intervals.

NASA's **Fundamental Aeronautics** Program (FAP) conducts research in all aeronautics disciplines that enable the design of vehicles that fly through any atmosphere at any speed. For FY 2010, all ARMD research into planetary entry, descent and landing (EDL) has been consolidated into the Hypersonics project in FAP. EDL is an integral part of many space missions and is not easily divided into distinct hypersonic and supersonic phases. This change will provide more focus to technical developments and will also yield technical management efficiencies. The FAP program has supported the testing of various new concepts that will help enable much improved capabilities for future vehicles. For example, wind-tunnel testing was conducted for several promising powered lift concepts. Powered lift concepts increase lifting force on an aircraft at slow speeds (e.g., at take-off and landing) without increasing drag under cruise conditions. Successful use of the concepts will enable short take-off and landings on runways less than 3,000 feet, which will increase next-generation air transportation system capacity through the use of shorter fields and improved low-speed maneuverability in airport terminal areas. Testing was also completed for a Smart Material Actuated Rotor Technology (SMART) helicopter rotor, which offers the potential for significant noise and vibration reduction in rotorcraft. Future work includes technologies and advanced tools to evaluate the trades between noise, emissions, and performance of future aircraft entering service in the 2012–2015 timeframe. Additionally, with the transfer of technologies to be matured to system-level within ISRP, the Subsonic Fixed Wing (SFW) project is streamlining its research content. This is enabling new efficiencies across the foundational disciplines remaining in the project. The integrated system-level research in this program will be coordinated with on-going, long-term, foundational research within the three other research programs, and will focus specifically on maturing and integrating technologies in major vehicle systems and subsystems for accelerated transition to practical application.

NASA's **Aviation Safety** Program (AvSP) continues to develop tools and technologies to improve on today's incredibly safe air transportation system, while ensuring that future technologies can be safely incorporated to the system. Examples of advances that support this development include NASA's ongoing and new research into aircraft icing. For example, with current knowledge we cannot extrapolate how ice forms on a straight wing such as found on a turbo-prop to how it will form on a swept wing, or a radically new aircraft configuration. The Aviation Safety Program is tackling this with a combination of computational models and experiments in NASA's Icing Research Tunnel. We are establishing that, in high and cold flight conditions, ice can form deeper in jet engines than previously understood. NASA is working collaboratively with the FAA, industry and international partners, such as the National Research Council of Canada, to conduct tunnel tests of the underlying physics, to fly our instrumented S–3 Viking into such engine icing condi-

tions, and design upgrades to our Propulsion System Lab in which jet engines may be tested in detail. Additional future work in Aviation Safety includes addressing gaps in validation and verification of critical flight software, developing new data-analysis capabilities to mine aviation operational data for safety issues, examining the safety of new vehicle systems and structures, and tackling the biggest human factors issues in the NextGen flight deck.

NASA's **Aeronautics Test Program** (ATP) is focused on ensuring a healthy suite of facilities and platforms to meet the Nation's testing needs including the development of new test instrumentation and test technologies. As part of its continuous efforts to improve facility operational efficiencies, ATP initiated the National Force Measurement Technology Capability, to address the severe erosion of NASA's capability to utilize strain gage balances in wind tunnel testing. The National Partnership for Aeronautics Testing, a strategic partnership between NASA and the Department of Defense (DOD), recently commissioned a study of government-owned, mid-to-large supersonic facilities necessary to fulfill future air vehicle test requirements. The Program will continue to develop 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 capabilities.

Exploration Systems

Human space flight is important to America's political, economic, technological and scientific leadership. In the span of a few short years, NASA has already taken long strides in the formulation of strategies and programs to develop a robust program of space exploration. These critical steps will allow our nation to build the next-generation space flight vehicles that will carry humans and deliver cargo to the ISS and the Moon, and on to other destinations in our solar system. The President's FY 2010 budget request for Exploration Systems is $3,963.1 million, an increase of $457.6 million above the FY 2009 appropriation and $225.4 million above the planned FY 2010 level in last year's request. Based on the Recovery Act funds and the President's increased budget request for FY 2010, the Exploration Systems budget plan includes about $630 million more in FY 2009 and FY 2010 than the previous plan. At this critical juncture, full funding at the President's requested level is essential for expediting development of new U.S. human space flight systems to support the International Space Station and explore the Moon and other destinations beyond low-Earth orbit.

The **Constellation** Program will apply additional Recovery Act funds to critical activities related to the successful completion of the Orion, Ares I and Ground Operations projects. The Commercial Crew and Cargo Program plans to use Recovery Act funds to stimulate efforts within the private sector in order to develop and demonstrate technologies that enable commercial human space flight capabilities—efforts that are intended to foster entrepreneurial activity leading to job growth in engineering, analysis, design, and research, and to economic growth as capabilities for new markets are created.

Following the Review of U.S. Human Space Flight activities, the Administration will provide an updated request for Exploration activities, as necessary. In the meantime, NASA is proceeding as planned with current Exploration activities, including Ares I, Orion, Commercial Crew and Cargo efforts, and lunar systems.

During the past year, NASA Exploration Systems continued to make significant progress in developing the next-generation U.S. human space flight vehicles and their associated ground and mission support systems. In the next several weeks, the first lunar robotic mission, the Lunar Reconnaissance Orbiter and the Lunar Crater Observation Sensing Satellite spacecraft, will be launched from the Cape Canaveral Air Force Station aboard an Atlas V, which will help NASA scout for potential lunar landing and outpost sites. Later this year, two major test flights for the Constellation Program will be conducted: Ares I–X is the first developmental test flight to support the design of the Ares I Crew Launch Vehicle; and the Pad Abort 1 (PA–1) is the first test of the Launch Abort System to be used on the Orion Crew Exploration Vehicle. NASA will continue to work with other nations and the commercial sector to coordinate planning, leverage investment, and identify opportunities for specific collaboration on Exploration activities.

The Constellation Program continues to complete the formulation phase of its projects—in particular Ares I, Orion, and major ground facilities. Major development work is underway, contracts are in place; and we have a dedicated group of civil servants and contractors who are all working hard to accomplish the Constellation Program's objectives. So far, NASA engineers have conducted about 6,500 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 the Ares I–X test flight, will lay the groundwork for maturing the Ares I final design prior to

its Critical Design Review (CDR). When launched later this year from NASA's Kennedy Space Center in Florida, the Ares I–X will climb about 25 miles in a two-minute powered test of the First Stage performance and the First Stage separation and parachute recovery system. Work on the Orion Project also continues to advance. Recently, NASA conducted testing of the water recovery process for the Orion capsule, and NASA also selected the material for Orion's heat shield. Later this year, Orion's PA–1 test will take place at White Sands Missile Range, New Mexico. PA–1 will demonstrate the Launch Abort System's ability to pull crew to safety should there be an emergency while the Orion and Ares I stack is still on the launch pad.

In September 2008, Ares I completed a key milestone with its Preliminary Design Review (PDR). PDR is the final step of the initial design process, and thereby a crucial milestone during which the overall project verifies that the preliminary design can meet all requirements within acceptable risk limits and within cost and schedule constraints, and identifies technical and management challenges and addresses approaches for eliminating or mitigating them. This fall, the Orion is expected to have progressed to the point of completing PDR, and obtaining Agency approval to proceed to Critical Design Review (CDR). Current plans call for Ares I to progress to the point of obtaining Agency approval by early 2010 to proceed to CDR.

As part of the Commercial Crew and Cargo Program and its associated Commercial Orbital Transportation Services (COTS) cargo projects, NASA is completing its promised $500 million investment to the two funded COTS partners, Space Exploration Technologies Corporation (SpaceX) of El Segundo, California, and Orbital Sciences Corporation (Orbital) of Dulles, Virginia. Recently, SpaceX successfully operated the full complement of the first stage engines of the Falcon 9, the SpaceX launch vehicle. Orbital continues to progress in achieving engineering milestones, and completed its PDR earlier this month. In addition, NASA has two non-funded COTS partners.

The transition of NASA facilities, infrastructure, property, and personnel from the Space Shuttle Program to the Constellation Program continues to be a major activity. 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 in order to leverage existing Shuttle and Space Station assets for NASA's future Exploration activities.

NASA's **Advanced Capabilities** programs include the Human Research Program (HRP) and the Exploration Technology Development Program (ETDP). These programs continue to reduce risks for human explorers of the Moon and beyond by conducting research and developing new technologies to aid future explorers. HRP focuses on the highest risks to crew health and performance during exploration missions while also developing and validating a suite of human health countermeasures to facilitate long-duration space travel. For example, NASA is conducting research to better understand the effect of space radiation on humans and to develop effective mitigation strategies. This year, HRP delivered a space radiation risk assessment tool, provided cockpit display design requirements for the Orion spacecraft, and provided design requirements for the new Constellation Space Suit System. HRP is also conducting research on-board the ISS with regard to: the cardiac structure and function of astronauts; radiation shielding technologies; and, the effect that certain pharmaceuticals may have on the prevention of bone loss during long-duration missions. ETDP will conduct a range of activities, including testing cryogenic hydrogen and methane propulsion systems for future missions; developing a small pressurized rover for transporting astronauts on the lunar surface; and demonstrating the capability to produce oxygen from lunar soil. ETDP also is conducting experiments on the Space Station to investigate the behavior of fluids and combustion in microgravity, and operating instruments to monitor atmospheric contaminants on the Space Station.

Space Operations

The FY 2010 budget request includes $6,175.6 million for Space Operations.

It is an exciting time for NASA's **Space Shuttle Program.** At this moment, the astronauts of Shuttle Atlantis are in orbit on STS–125, the final mission to service the Hubble Space Telescope. We anticipate that the work they are doing, which includes upgrading the Hubble's instruments, should extend the observatory's operational life several years. The President's FY 2010 budget funds the safe flight of the Space Shuttle to conduct its remaining missions, including the AMS flight and completing assembly of the ISS. NASA is committed to completing the eight remaining scheduled Shuttle flights, which we believe can be accomplished by the end of 2010. These Shuttle flights will leave the ISS in a configuration to support a broad portfolio of research and to receive and be maintained by commercial cargo services.

The FY 2010 budget request includes $3,157.1 million for the Space Shuttle Program.

NASA and its Russian, European, Canadian, and Japanese **International Space Station** partners are working together to realize one of the most inspiring dreams of the last 50 years: the establishment of a station in Earth orbit for the conduct of various types of research. We are now approaching two significant milestones. In May, the ISS will host its first six-person crew. The recent delivery of the Station's final set of solar arrays and other equipment by the crew of STS–119 represents the final step toward this goal. In June, the STS–127 mission will deliver the third and final component of the Japanese *Kibo* laboratory—the *Kibo* Exposed Facility. The addition of the Exposed facility enables the *Kibo* laboratory, with the European *Columbus* module and the U.S. *Destiny* module, to complete the three major international science labs on ISS, setting the stage for utilization of ISS as a highly capable microgravity research facility. The President's FY 2010 budget request includes $2,267.0 million for the ISS.

The ISS will represent both an unparalleled international cooperative effort and a U.S. National Laboratory in orbit. Scientists will be able to conduct biomedical and engineering research from a unique vantage point. Some of the work will increase our knowledge of the effects of long-duration human space flight, which is critical for the design and operation of future human space vehicles, including those being developed under the Constellation Program to return U.S. astronauts to the Moon and explore other destinations. Other research will not be focused on space exploration at all, but may have significant applications right here on Earth. Medical research, for example, may be applicable to the development of vaccines; NASA's research into *Salmonella* aboard the Space Shuttle and ISS has already increased our knowledge in this area. In the key areas of energy and the environment, the ISS serves as a daily demonstration of ''green'' technologies and environmental management techniques. The ISS receives 120kW of power from its solar arrays to operate the Station and run experiments. The ISS environmental system is designed to minimize the amount of mass that has to be launched from Earth to support the Station, so recycling is a must. STS–119 supplied ISS with a replacement Distillation Assembly for Station's water recycling system, which is key for supporting a full six-person crew for extended periods of time. Given the central role science and technology play in our society, it is important that the United States maintain a leadership role in these fields. The availability of a research laboratory in the microgravity environment of space will support this aim.

Another benefit from Space Shuttle missions and ISS research is reflected in the programs' ability to inspire the next generation of Americans. This was reflected recently in the delighted faces of students who participated in the up-linked phone call between President Obama and the crews of the ISS and STS–119 on March 24. The ISS will support the President's goal of making math and science education a national priority by demonstrating what can be accomplished through science and engineering, and by inspiring both teachers and students.

NASA is relying on U.S. industry to develop vehicles to deliver supplies and experiments to the ISS. In December 2008, the Agency awarded two Commercial Resupply Services (CRS) contracts for the provision of this critical capability. Cargo resupply is important for the continued viability of ISS. In addition, the vendors involved will gain valuable experience in the development and operation of vehicles that can 1) fly to the ISS orbit; 2) operate in close proximity to the ISS and other docked vehicles; 3) dock to ISS; and, 4) remain docked for extended periods of time.

The FY 2010 budget request includes $751.5 million for **Space and Flight Support,** which supports Space Communications and Navigation, Launch Services, Rocket Propulsion Testing, Crew Health and Safety, and the new Human Space Flight Operations programs.

Education

The FY 2010 budget request for Education totals $126.1 million and furthers NASA's commitment to Science, Technology, Engineering, and Mathematics (STEM) education. NASA will continue its successes in developing a future aerospace workforce, improving the technological competitiveness of our nation's universities, attracting and retaining students in STEM disciplines, and engaging the public in NASA's missions. NASA will accomplish these goals by offering competitive research grants to universities, providing targeted educational support to Minority Serving Institutions, and strengthening curricula at two-year community colleges. NASA's plans to streamline and centralize internship and fellowship application processes will realize cost savings and facilitate student access to information while attracting a wider, more diverse participant base. The Agency is also seeking new opportunities for student involvement in current space and aeronautics research missions and

flight projects, including those using high altitude balloons, sounding rocket payloads, airborne sensors, and space satellites. NASA will further these efforts through a new project, Innovation in STEM Education, which will allow the Agency to investigate and offer opportunities for student and faculty to participate in NASA-related research. In coming months, the Agency will complete award announcements for competitive grant programs in K–12, global climate change, and informal education, and revise and issue new solicitations using FY 2009 funds.

NASA will further pursue a goal to attract and retain students in STEM disciplines in the upcoming fiscal year. Last year, the Interdisciplinary National Science Program Incorporating Research & Education (INSPIRE) program engaged over 200 high schools in STEM areas, and NASA Explorer Schools conducted instructional and enrichment activities that reached over 105,000 students. The March 2009 STS–119 mission also provided a unique educational opportunity as two Mission Specialists who are science teachers, Joe Acaba and Richard Arnold, were part of the crew. NASA Education continues to provide internships, fellowships, and research opportunities to help students and educators gain hands-on experiences in a range of STEM-related areas. These opportunities provide students with the motivation, inspiration, and experience needed to serve the Nation's current and future workforce needs. In FY 2008, the Agency provided more than 3,000 summer internships, reached 5,331 students through significant research experience or grants, and provided 139 grants to under-represented and under-served institutions.

NASA will also engage elementary and secondary school and informal education audiences by using Earth and deep space observations, the flight experience of Educator Astronaut Dorothy Metcalf-Lindenburger aboard STS–131, as well as future missions to the Moon and other destinations. New technologies such as social networks, Internet collaborations, a new virtual magnet school, and remote control of science instruments will expand and enhance these efforts. In FY 2010, NASA also plans to provide an online professional development system for students training to become educators, in-service teachers, and informal educators. Additionally, NASA will promote continuous public awareness of its mission and improvement to STEM literacy by partnering with informal education providers, which allows Agency partners to share the excitement of NASA missions with their visitors in meaningful ways.

Cross-Agency Support

NASA Cross-Agency Support provides critical mission support activities that are necessary to ensure the efficient and effective operation and administration of the Agency, but cannot be directly aligned to a specific program or project requirement. These important functions align and sustain institutional and program capabilities to support NASA missions by leveraging resources to meet mission needs, establishing Agency-wide capabilities, and providing institutional checks and balances. Cross-Agency Support includes Center Management and Operations, Institutional Investments, and Agency Management and Operations. The FY 2010 budget request includes $3,400.6 million for Cross Agency Support.

Center Management and Operations funds the critical ongoing management, operations, and maintenance of nine NASA Centers and major component facilities. NASA Centers continue to provide high-quality support and the technical talent for the execution of programs and projects. The FY 2010 budget request includes $2.084 million for Center Management and Operations.

Institutional Investments funds design and execution of non-programmatic revitalization construction of facilities projects, demolition projects for closed facilities, and environmental compliance and restoration activities. The Construction of Facilities Program makes capital repairs and improvements to NASA's critical infrastructure to improve safety and security and improve NASA's operating efficiency by reducing utility usage. NASA continues to right size the infrastructure by demolishing facilities that are no longer needed. Emphasis has been placed on energy and water conservation. Currently, NASA has five buildings that are certified under the Leadership in Energy and Environmental Design (LEED) criteria, three additional buildings that are built and awaiting certification as LEED Silver facilities, and 13 buildings in various stages of design and construction as High Performance Buildings and are expected to be LEED-certified when completed. The FY 2010 budget request includes $355.4 million for Institutional Investments.

NASA's FY 2010 request includes $961.2 million for **Agency Management and Operations,** which funds the critical management and oversight of Agency missions, programs and functions, and performance of NASA-wide activities, including five programs: Agency Management, Safety and Mission Success, Agency Information Technology Services, Innovative Partnerships Program, and Strategic Capabilities Assets Program.

The FY 2010 budget request provides $412.7 million for **Agency Management,** which supports executive-based, Agency-level functional and administrative management requirements. Agency Management provides for the operational costs of Headquarters as an installation; institutional and management requirements for multiple Agency functions; assessment and evaluation of NASA program and mission performance; strategic planning; and independent technical assessments of Agency programs.

The FY 2010 budget request provides $183.9 million for **Safety and Mission Success** activities required to continue strengthening the workforce, training, and strengthening the fundamental and robust cross-checks applied on the execution of NASA's mission, and to improve the likelihood for safety and mission success for NASA's programs, projects, and operations. The engineering, safety and mission assurance, health and medical independent oversight, and technical authority components are essential to NASA's success and were established or modified in direct response to many of the key *Challenger* and *Columbia* accident board recommendations for reducing the likelihood for future accidents. Included under Safety and Mission Success is the Software Independent Verification and Validation program.

The FY 2010 budget request for **Agency Information Technology Services** is $150.4 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. NASA plans significant emphasis on continued implementation of five major Agency-wide procurements to achieve the following: (1) consolidation of IT networks leading to improved network management, (2) consolidation of desktop/laptop computer services and mobile devices to improve end-user services, (3) data center consolidation to provide more cost-effective services, (4) Agency public web site management to improve access to NASA data and information by the public, and (5) Agency business systems development and maintenance to provide more efficient and effective business systems. NASA will also continue to improve security incident detection, response, and management through the Security Operations Center.

The request for the **Innovative Partnerships Program** (IPP) is $184.8 million. IPP works with all four Mission Directorates to provide innovations meeting NASA's technology needs, and transfers NASA technology for broad Spinoff applications that improve quality of life and contribute to economic growth. Included in the IPP portfolio are: NASA's SBIR/STTR Programs seeking out innovative high-technology small businesses; a new Innovative Technology Project seeking high-impact revolutionary research and technology projects; a Seed Fund to address technology needs through cost-shared, joint-development partnerships; use of commercial flight services by the FAST program to demonstrate new technologies; Innovation Ambassadors to exchange ideas; and the Centennial Challenges prize program for the citizen inventor. IPP seeks partnerships through offices at all 10 NASA Centers.

Finally, NASA is requesting $29.4 million in FY 2010 for the **Strategic Capabilities Assets Program** (SCAP). This program funds the costs required to sustain key Agency test capabilities and assets, such as an array of flight simulators, thermal vacuum chambers, and arc jets, to ensure mission success. SCAP ensures that assets and capabilities deemed vital to NASA's current and future success are sustained in order to serve Agency and national needs. All assets and capabilities identified for sustainment either have validated mission requirements or have been identified as potentially required for future missions.

Conclusion

The President's FY 2010 budget request for NASA supports the Administration's commitment to deploy a global climate change research and monitoring system, funds a robust program of space exploration involving humans and robots with a goal to return Americans to the Moon by 2020 and explore other destinations, and funds the safe flight of the Shuttle to complete assembly of the ISS through its retirement, planned for the end of 2010. The FY 2010 budget request funds continued use of the ISS to enable the Agency to develop, test, and validate critical exploration technologies and processes and, in coordination with our international partners, to make the ISS available support other government entities, commercial industry and academic institutions to conduct unique research in the microgravity environment of space. It will also stimulate private sector development and demonstration of vehicles that may support NASA's cargo and crew requirements. And it renews NASA's commitment to aeronautics research to address fundamental aeronautics, aviation safety, air traffic management, and mitigating the impact of aviation on the environment. NASA's diverse portfolio of science, technology, engineering and mathematics (STEM) educational activities is also aligned with the Administration's goal of improving American innovation and global competitiveness. NASA looks forward

to working with the Committee on implementation of the detailed FY 2010 budget request.

Mr. Chairman, thank you for your support and that of this committee. I would be pleased to respond to any questions you or the other Members of the Committee may have.

BIOGRAPHY FOR CHRISTOPHER J. SCOLESE

Since January 20, 2009, Mr. Christopher J. Scolese has been serving as the Acting Administrator of the National Aeronautics and Space Administration (NASA). As the Acting Administrator, Mr. Scolese is responsible for leading the development, design, and implementation of the Nation's civil space program. As such, Mr. Scolese provides overall leadership for NASA's multiple field installations, works closely with the Executive and Legislative branches to ensure that NASA is supporting appropriate national policy, and leads an international collaboration in carrying out high-profile space missions including the Space Shuttle, the International Space Station, the Hubble Space Telescope, and a multitude of other scientific and technological efforts.

In addition, Mr. Scolese is still serving in the position of Associate Administrator, NASA's highest-ranking civil servant. As Associate Administrator, Mr. Scolese is responsible for the oversight and integration of NASA's programmatic and technical efforts to ensure the successful accomplishment of the Agency's overall mission.

Previously, Mr. Scolese served as NASA's Chief Engineer. As Chief Engineer, Mr. Scolese was responsible for ensuring that development efforts and mission operations within the Agency were planned and conducted on a sound engineering basis, as well as for the long-term health of the NASA engineering workforce.

Formerly, Mr. Scolese was the Deputy Director of the Goddard Space Flight Center where he assisted the Director in overseeing all activities. He also served as the Deputy Associate Administrator in the Office of Space Science at NASA Headquarters. In this position, he was responsible for the management, direction and oversight of NASA's Space Science Flight Program, mission studies, technology development and overall contract management of the Jet Propulsion Laboratory. Mr. Scolese also served as the Earth Orbiting Satellite (EOS) Program Manager and the Deputy Director of Flight Programs and Projects for Earth Science at Goddard. In these positions, he was responsible for the operation and development of all Earth Science missions assigned to Goddard. While there, he also served as the EOS Terra Project Manager. In addition, Mr. Scolese was the EOS Systems Manager responsible for the EOS system architecture and the integration of all facets of the project. During his tenure at Goddard, he chaired the EOS Blue Team that re-scoped the EOS Program; he supported the EOS investigators in the development of the EOS payloads in the restructured EOS; and he has been responsible for the adoption of common data system architecture on EOS and some other Earth orbiting spacecraft. Prior to his 1987 appointment at Goddard, Mr. Scolese's experience included work in industry and government. While a senior analyst at the General Research Corporation of McLean, Va., he participated in several SDIO programs. He was selected by Admiral Hyman Rickover to serve at Naval Reactors where he was associated with the development of instrumentation, instrument systems and multi-processor systems for the U.S. Navy and the DOE while working for NAVSEA. Mr. Scolese is the recipient of several honors including the Presidential Rank Award of Meritorious Executive, Goddard Outstanding Leadership, two NASA Outstanding Leadership Medals and the American Institute of Aeronautics and Astronautics (AIAA) National Capital Section Young Engineer/Scientist of the Year award. He was recognized as one of the outstanding young men in America in 1986, was a member of college honor societies including Eta Kappa Nu and Tau Beta Pi, and was recipient of the 1973 Calspan Aeronautics award. He is a Fellow of the AIAA and a member of the Institute of Electrical and Electronics Engineers. He also served as a member of the AIAA Astrodynamics Technical Committee and chaired the National Capitol Section Guidance Navigation and Control Technical Committee.

DISCUSSION

Chairman GORDON. Well, we are down to a little over seven minutes, so I think probably—on this coming vote, so I think the best thing for us to do is to recess, and I would ask all of our Members to try to come back as promptly as they can after this series of votes, and we will then move forward with the questions.

[Recess.]

Chairman GORDON. All right. We will reconvene, and we thank you, Mr. Scolese, for your patience, and at this point we will start a round of questionings, and the Chairman recognizes himself for five minutes.

ISS RE-SUPPLYING

Mr. Scolese, as you know, Congress has made significant contribution to the International Space Station in our—and at the same time we really don't have a clear path to re-supplying the Space Station other than hoping that the private sector is going to move forward.

Is there a plan B, and is there any type of discussion going on with international partners in case this does not work out?

Mr. SCOLESE. Well, as you know, the plan for re-supplying the station goes through part of the eight flights that we have——

Chairman GORDON. Right.

Mr. SCOLESE.—of the Shuttle, and then we do have our international partners that do have—on the European side the ATV and the Japanese side the HTV that provided, but to fill the gap between what they can provide and progress we are relying on the commercial sector to go off and do that, and at this stage there is no plan B.

Chairman GORDON. And so how long do you see us having there?

Mr. SCOLESE. Well, we are not anticipating a gap. Right now with the eight Shuttle flights, if we complete them, you know, roughly in the 2010 timeframe, we will have pre-positioned enough of the large spares and other resources that we need that will carry us through as we anticipate the commercial capability coming on board, assuming that the ATV, the HTV, and the Progress vehicles are performed per planned.

Chairman GORDON. And when are they—what is the timeframe on those?

Mr. SCOLESE. The ATV has already demonstrated its capability to rendezvous with the Station last year. I believe the next flight is next year. The HTV is scheduled for this fall. That will be the first flight of the Japanese module, the Japanese capability, and of course, Progress has been going for some time and the commercial capability is expected in the 2012 timeframe, I believe.

Chairman GORDON. Okay.

Mr. Hall, you are recognized for five minutes.

Mr. HALL. Thank you, Mr. Chairman, and I will try to be as brief as I can.

As I said in my opening remarks, I am not in favor of more deficit spending, but I believe we have to prioritize, and I think in my opinion closing the gap in our human space flight capability is a goal that should have been given a higher priority in the fiscal year 2009 Recovery Act, and as it is I am encouraged that the fiscal year 2009 stimulus funding combined with the fiscal year 2010 request ought to give the exploration system an increase of about $630 million.

By that is not, that is over two years, and it is critical to keeping the Constellation on schedule but it doesn't do a lot about those four years that we are losing.

NEGATIVE EFFECTS OF INSUFFICIENT FUNDS

Mr. Scolese, if—I will give you one you can knock out of the park here. If the 302B budget allocations are not sufficient or if NASA is not appropriated the money that you are asking for, why don't you just explain to the Committee and to those that will read it, and actually, this is made available to all Members of Congress and anybody anywhere can read it, what are the negative effects to exploration goals if sufficient funds are not allocated as we have asked for?

Mr. SCOLESE. Well, frankly, sir, we won't make IOC.

Mr. HALL. What will that do to our partners, worldwide people that believe in us and join with us in pursuits?

Mr. SCOLESE. I think we will let them down. I mean, frankly, you know, the plan is that we will be able to start carrying crew up to the Space Station in 2015, so we would have to rely even further on the Russians to carry crew up and down from the Station. That clearly isn't good for our international partners, it is not good for this country, and it would further delay the, you know, the human lunar return, and it, depending on how severe the reduction was, it may even impair what we were just talking about now with the commercial cargo re-supply. So it could potentially impact the Space Station's liability for the future as well.

Mr. HALL. And probably would.

Mr. SCOLESE. And probably would.

Mr. HALL. And in your wildest estimation or maybe outright guess, can you envision some time in the future, sometime, somewhere a situation where we might need all the sophistication in space we can to defend a war?

Mr. SCOLESE. Sir, I think we need it today.

Mr. HALL. Yes, sir, and I do, too.

Mr. SCOLESE. And, I mean, we—if you look at what space provides us in terms of communications, our understanding of the weather and climate and preventing natural disasters and just tracking hurricanes as an example, plus the capabilities that we get by having, you know, the ability of humans to go off and do things in space as we have just seen over the last couple of weeks with Hubble.

So I think we are already a space-dependent civilization, and we cut back, we are going to lose significantly.

Mr. HALL. You are giving us the negative effects, and I think, I hope those that think three percent is a gross amount of the budget to allocate to something as important as space are daydreaming.

Thank you. I yield back.

Chairman GORDON. Ms. Giffords is recognized for five minutes.

Ms. GIFFORDS. Thank you, Mr. Chairman, and thank you, Mr. Scolese, for being here and for your service to NASA and to our country.

BUDGET PLAN FOR 2020 GOAL

Norm Augustine, of course, who is heading up the human space flight review, testified before our committee in 2004, and he said it would be a grave mistake to try to pursue a space program on the cheap. To do so in my opinion is an invitation to disaster. And

I don't mean to beat a dead horse, but obviously we are really concerned that the 2010 budget looks positive, but I am more concerned, as the Members are, about the out-year budget that would cut more than $3 billion for the Exploration program, adding to cuts made in previous years and essentially halting the work on the Ares V Heavy-Lift Launch Vehicle and the Altair Lunar Lander.

Your testimony confirms, and we have heard the President talk about the mission of going back to the Moon by 2020, but I don't know how we are going to be able to achieve this, given the budget plan.

So Mr. Scolese, how does NASA plan to achieve the 2020 goal under the budget that is being proposed, and also, based on the fiscal year 2010 budget request, do you have sufficient funding to maintain the current schedule for completion of Ares I and Orion?

Mr. SCOLESE. On the last part first, we believe with the current budget we can complete Ares I and Orion and the associated elements by 2015. You may recall in previous testimony by Administrator Griffin that we needed additional resources to try and accelerate and hold the 2015 date, and we needed those resources in 2008, '09, and '10. We received them in '09 and '10, so that helps us, you know, considerably with Ares I and Orion and all the associated elements. And in fact, you can see a lot of those coming together. Anybody that visits Kennedy Space Center will see that going on today, as well as our other facilities.

As far as the other elements, we are in the process of evaluating what that means. We have not stopped work on Ares V. We are still doing some work on that, and some of that work comes from the development of Ares I, the solid rocket motor and the J–2 engine, are both integral to the Ares V, plus some additional work that is going on.

But the overall impact, we are in the process of assessing what that will mean in terms of our ability to do 2020, and what we do by 2020.

So I don't have a good answer for the impact but clearly the situation as it stands right now means that we couldn't do the program of record, putting humans on the Moon by 2020. We may be able to do something lesser in that timeframe, but we haven't completed the work to answer that question fully.

ITAR AND EXPORT CONTROLS

Ms. GIFFORDS. I know other Members are probably going to drill down a little bit harder on the budget, but I would like to shift gears. The Science and Tech Committee held a hearing earlier this year that looked at the current export controls regime that is current in our commercial space industry and the competitiveness factor for science and technology. I also serve on the Foreign Affairs Committee, and we are currently considering legislation that relates to export controls.

So I would be interested in your thoughts on how big an impact ITAR and export controls are having on NASA's ability to carry out our international space collaborations and joint research projects, and are there some problems that you can specifically talk about and ways that we could improve the situation?

Mr. SCOLESE. Yes. There are issues with ITAR. It does make our ability to work with our international partners more difficult from a NASA perspective. We have issues in how we can frankly go off and communicate issues, you know, technical information because we have to protect information and technologies that frankly are widely available. So it adds some additional complexities to what we do.

The bigger impact is probably to our industry where they have less opportunity to compete for work due to the delays that it takes to get licenses and the ability to sell on the market whatever they have. That, of course, hurts our industry, but it also hurts us because it provides us with less—the industry is doing less, therefore, our products are costing more as we become the main customer for industry rather than them sharing it. There is statistics on communication satellites where we held 60, 70 percent of the market, and we are down to 25 percent today. That has an impact on the industry obviously, but it has an impact on us because they were building satellites that we could take advantage of to buy down our costs for scientific satellites and other activities.

So it has impacts all the way across the board, and finally, there is an impact in our ability to work with people because it takes longer for us to get the authority to work with internationals that may have dual citizenship. So right across the spectrum it is an issue for us.

Ms. GIFFORDS. Thank you, Mr. Scolese. Thank you, Mr. Chairman.

Mr. HALL. The gentlelady yield?

Ms. GIFFORDS. Yes.

Mr. HALL. The President, I think, stated about three weeks ago that all of research and development ought to be three percent. I think that is vastly underrated. I think NASA alone needs one percent, and if that, if you escalate that up and put the other two points there out of the three percent, I think he is under-guessing maybe by a full percent or maybe two percent.

But NASA is terribly under-funded, and if we don't do something, we are going to be at Russia's mercy. I don't want to be there, and they are not going to finish the Constellation on time. We need to fly one bird and borrow off the other three and get that to go a couple of years and then have Constellation funded properly to where they could escalate the finishing, the completion of that.

You know, I hate to talk about World War II, but in World War II we had one aircraft carrier when we knew the Japanese was going to bomb Midway, and they were going to attack Midway. There was another aircraft carrier that came into Pearl Harbor several days after the Battle of the Coral Sea, it took seven months to repair it, but when they found out they was going to bomb Midway, they said do this in seven days, not seven months, and they did, and we had two carriers at Midway or we might not have won the battle in the Pacific. We need to tell the folks that are down, that are not sufficiently taking care of NASA that this is an emergency, too. This is very much an emergency because the next war might be fought out of space.

I yield back. Thank you.

Ms. GIFFORDS. Thank you, Mr. Hall. I believe I can speak for the Members of the Committee that we love your passion and having you on this committee, and it is an honor to serve with you. Thank you.

Chairman GORDON. Mr. Olson is recognized for five minutes.

Mr. OLSON. Thank you very much, Mr. Chairman, and Mr. Scolese, I just want to first of all say I applaud you for doing an outstanding job under some very trying circumstances. The task of leading NASA is difficult under normal situations, but the position you found yourself in is something that is not to be envied, and aside from the budgetary and the programmatic challenges you have overseen have been extremely successful and above all else we have got a safe Shuttle Mission which is going on as we speak. Front page here of the *Washington Post.*

Mr. SCOLESE. Thank you, sir. Yeah.

Mr. OLSON. There you go. Great, great stuff. And, again, I want to thank you and say congratulations on a job well done.

Mr. SCOLESE. Thank you, sir.

TRANSITION FROM THE SHUTTLE TO CONSTELLATION

Mr. OLSON. In terms of my questions I want to talk about could you please give us an update on the transition from the Shuttle to the Constellation? For example, I knew that we had to keep both of the launch pads at Kennedy in configuration for the Shuttle until this mission was complete, so one of them should be getting transitioned to the Ares I–X, and I just want an update on those type issues if you don't mind, sir.

Mr. SCOLESE. Certainly. The transition is going per plan. We are in the process of flying out the Shuttle Manifest. We have eight more flights now that Hubble is almost done. The workforce is starting to transition as some of the Shuttle people working Shuttle are also working on the Constellation or—sorry, on Ares or Orion.

As far as the progress that you can visibly see, at all of our centers it is probably most visible at the Kennedy Space Center when you look at—we have two pads, 39A and 39B. We launched the Shuttle off of 39A to go up to Hubble. Sitting on the adjacent pad, 39B, is the rescue vehicle, and we won't release that until we are ready to return to Earth with this mission.

But when you look at that pad, you can already see that is different. We have the lightning towers up, and once we roll that Shuttle back, we will turn it completely over to the Constellation Program. We have turned one of the mobile launch platforms over already to support to Ares I–X test that will happen later this year. We have had to delay it because we kept 39B. When you walk into the vehicle—the vertical assembly building at Cape, you will see the Ares I–X vehicle being built. It is being stacked. Every time I go down there I look at it, and I am absolutely impressed by the progress that the people are making on that. It is scheduled for launch later this year.

Go out the back of the VAB, and you will see the mobile launch platform, the new mobile launch platform, being built for the Ares I, and as you visit our various facilities at Johnson or Marshall or the contractor facilities in Denver, you can see some great progress

going on on the Orion vehicle, the ground support equipment, the launch site—excuse me, the launch site equipment. So we are making some very good progress on Orion and Ares as we speak.

NASA Perspective on Review Panel

Mr. OLSON. Thank you very much for that answer.

Shifting gears a little bit to the new Human Spaceflight Review Panel, just wanted to get a sense for what so the employees at NASA from your perspective sort of think about that review panel? I mean, are there concerns, are they pleased that it is proceeding? Just want to sort of get your kind of lay of the land on how that is with the personnel.

Mr. SCOLESE. Well, I think it is fair to say it is mixed. No one likes to take a test, and this is a test. Some people clearly recognize the value of the review given some of the questions that have been opened, and they clearly are relieved and recognize the objectivity and openness of Norm Augustine leading the panel, you know, identifies the seriousness that the Administration takes in coming up with a good answer.

What I can say is that while people are concerned, I am sure they are, they are going to go off and demonstrate that they are making the right progress and they are doing the right things, and they will be fully open with the team and provide them with whatever information that they need. And I think in the end we will have a good outcome, and I think the team recognizes that, too.

Mr. OLSON. Thank you very much for that question. I agree with that. I mean, I think our problem has been not a vision but just a lack of commitment on our part to put the resources we need to it, but thank you, and I yield back my time.

Chairman GORDON. We will move from Houston down to Marshall Spaceflight Center and Dr. Griffith.

International Competition

Mr. GRIFFITH. Thank you very much. Appreciate you being here. I think America had this conversation about a half a century ago when we were challenged by the Russians. We are having it again, and the question is are we committed. Can we do it again? Are we ready to accept the challenge?

China is walking in space, six weeks ago Russia is up, India is going up, Iran has launched its satellite, and in my opinion, although the Saturn is the 8th wonder of the world, we have another one on the drawing board, and that is our Ares V. I don't think it is an option for America. I think it is an essential for America to maintain its position. I think it has to happen. I think Norm Augustine's commission should not be reviewing whether or not human space exploration is a possibility, feasibility. We are the wealthiest country in the world. We know that it is. What we want him to say is how can we get there and explain to the public and to the Administration that we are under-funded.

And so with that you have done a great job, and we appreciate you very much and all of the team that is working on the Constellation Project.

Thank you.

Mr. SCOLESE. Thank you, sir.
Chairman GORDON. Where do you stand on that?
Mr. GRIFFITH. I have watched too many space flights.
Chairman GORDON. Dr. Ehlers.

MARS AND MOON PROGRAMS

Mr. EHLERS. Thank you, Mr. Chairman. It is good to be—you recognize someone who doesn't, whose district doesn't benefit materially from the activities of NASA.

Just a couple of questions. On the Mars Exploration Program, you mentioned the MSL and what you are doing there, but what else do you have going in the Mars Program? Do you have more robotic satellites planned, and is there still any discussion at all of manned venture or human ventures to Mars?

Mr. SCOLESE. Yes, sir. We have besides MSL we recently selected the MAVEN Mission, which is a competitively-selected mission in our Scout Program to go off and look at the atmosphere of Mars and understand its composition. In addition, we have started a partnership with the Europeans to do an aggressive mission on Mars and in orbit around Mars for the 2016 opportunity. That will start building up more and more towards greater and greater capability at Mars.

As you know, we already have a number of satellites around Mars, and we have vehicles on the surface of Mars. We are trying to get Spirit unstuck, and we are working on that, but we have two rovers that are still on Mars. And they are doing the reconnaissance that—as well as the exploration to understand more about Mars. They are also doing the reconnaissance for potential human missions.

And the program of Constellation that we were just talking about with the heavy-lift launch vehicles and the capabilities that we are developing has as its ultimate goal to get humans to Mars at some time in the future.

So we are still looking towards Mars and looking how to do that with humans. As you know, Mars presents more biological challenges almost than the physical ones to keep a crew alive for three or four years in space is quite a challenge, but that is a goal of the program, to take humans to Mars.

Mr. EHLERS. I assume you also hope to return them to Earth.

Mr. SCOLESE. Yes, we do. Alive.

Mr. EHLERS. You haven't mentioned that part. That is where all the expense really comes in.

Mr. SCOLESE. That is right.

Mr. EHLERS. Maintaining and the coming back. You could probably find lots of volunteers who don't mind whether they come back.

Mr. SCOLESE. Go one way. No. I don't think you want to do that.

Mr. EHLERS. No. I agree. I do also incidentally want to thank you for the work on the Hubble. I was one of the chief agitators against the initial decision not to repair it, and I was sort of pleased when Mike Griffin make the decision to go for it, and I assume it will pay off, you know. We don't know how long it is going to be able to continue, but it has been such a wonderful addition to the

science and astronomy of the universe that it would be a shame to let it die before we get the next one up.

Mr. SCOLESE. That is correct, sir.

Mr. EHLERS. So I appreciate your good work on that.

I was half serious about the manned or human mission to Mars. I got the impression when the President in the previous Administration announced that there was an attempt to give NASA personnel a shot in the arm, but I just didn't see much in the way of specifics about what we hoped to do and what we hoped to gain from that mission. And I am also not clear how that relates to the Moon exploration and why we believe it is important to go to the Moon at this point.

So I would appreciate some clarification on that.

Mr. SCOLESE. Well, there hasn't been much on the Mars, the human Mars mission because of the distances involved, and as I said, the, you know, keeping the crew alive for that amount of time. We have been focusing on getting the new capability developed, but as we develop that capability, we are recognizing that the things that may be needed to carry a crew to Mars, as well as other destinations that are out there in the solar system, as well as other capabilities that are provided for by a vehicle like an Ares V.

Why go back to the Moon? There is lots of reasons for going back to the Moon. One is to practice. We have not landed with humans on another planetary body since Apollo 17 in the early 1970s, and we need to go off and develop those skills again as a very minimum if we are going to go there.

And, of course, you know, the Moon provides an opportunity to practice those capabilities in a relatively safer environment where you are only three days away from Earth as opposed to months or years away from Earth, as well as the scientific benefits and the potential commercial benefits of the Moon that we will be looking at.

Mr. EHLERS. Well, let me just comment that I think—you haven't mentioned anything about new propulsion systems. I think that is basically your biggest problem. Trying to use chemical propellants to get to Mars and back, particularly to get the crew back off the surface. It is a huge problem and a huge expense.

Mr. SCOLESE. Absolutely.

Mr. EHLERS. Are you investigating other systems that might be far better than using chemical propellants?

Mr. SCOLESE. For in-space propulsion? That is one of the areas that, unfortunately, we don't have as much investment in as we would like. The activities looking at alternative types of propellants, nuclear propulsion, and nuclear electric have mostly been for smaller missions, but that is an area that clearly we could—we would like to do it, but we don't have the resources right now.

Chairman GORDON. Thank you, Dr. Ehlers, and Ms. Fudge is recommended—is recognized.

Ms. FUDGE. Thank you, Mr. Chairman. Good afternoon.

GLENN RESEARCH CENTER

Just a couple of questions. One is I happen to come from an area where NASA Glenn is located, so my questions will be about NASA Glenn.

I was very interested to read in your prepared statement that you are looking at and addressing some computational models and experiments in the Icing Research Tunnel at NASA, at Glenn Research Center, and I am just curious, do you think that if the Glenn Icing Research Tunnel, which is a very, very old structure, it was built right after World War II, would be more productive if it were modernized?

Mr. SCOLESE. We are looking at modernization of various facilities. I am not 100 percent sure if that is one of them, so I couldn't say sitting here, but we can get back to you on that.

Ms. FUDGE. Okay.

Mr. SCOLESE. But we are looking at revitalizing and upgrading facilities where possible and when needed.

Ms. FUDGE. Well, additionally, are you making use of other aviation safety issues that—you know, Glenn has, does have an expertise in propulsion. Are you using that expertise in any other way?

Mr. SCOLESE. We—if the question is are we using Glenn's capabilities to develop improved propulsion systems for aviation——

Ms. FUDGE. Yes.

Mr. SCOLESE.—the answer is yes and in a broad spectrum of areas so we are. We have the test capabilities there. Also in—actually in rocket propulsion, electric propulsion Glenn is the leader there, so they are working on capabilities there for electric propulsion.

Also in a small way for robotic systems. Although it is not directly propulsioned, it is providing power. Glenn is leading the effort to develop new and improved ways of developing RTGs, where we work with the Department of Energy, and they provide radioactive source, and we more efficiently convert that heat into electricity that can be used for propulsion or used for keeping the systems alive, particularly when they are far away from the sun.

And let us see. I have a note here that says that we are, in fact, using some Recovery—of the Recovery Act funds to repair the refrigeration systems on the Icing Research Tunnel at Glenn.

Ms. FUDGE. Very good.

Mr. SCOLESE. So——

Ms. FUDGE. Thank you. Thank you, Mr. Chairman. I yield back. Oh, Ms. Chairman. Thank you.

Ms. GIFFORDS. [Presiding] Thank you, Ms. Fudge.

The Chairman recognizes Mr. McCaul.

MOON PROGRAM AND CYBER SECURITY

Mr. MCCAUL. Thank you, Madam Chair. Welcome and good to see you again, and I have several NASA employees and contractors. I have Houston in my District. I just recently took Dr. Anna Fisher through my schools and a delightful astronaut. I thought that was a great thing to do with the kids, get their excitement, and they are all, they always wonder, well, we were on the Moon in 1969, and why are we looking at 2020 and of course, you have to explain you have to build a station on the Moon.

A lot of the concerns that we have looking at this budget have already been talked about, but I wanted to reiterate them and that is the cut in the Constellation systems of $3 billion, eliminating the

development of the Ares V Heavy-Lift Launch, and the Altair Lunar Lander.

Is all that possible to cut those programs as severely as this budget does and still get to the Moon by 2020?

Mr. SCOLESE. Well, that is what we are evaluating right now, and as I mentioned earlier, the architecture allows for Ares V development, if you will, to continue because the Ares I has a solid that is similar to what we are going to have on Ares V, it has the J2–X engine on its upper stage, which is what we want to use on Ares V, and we do have some funding in there to continue the studies and development of Ares V.

Altair is something that we have to look at further. That is the lander, as you know, to land on the Moon. We developed a conceptual study, and we need to go off and refine that. It is impacted by this budget, and that will be part of the product that comes out of this study that we were talking about earlier that Norm Augustine is going to lead. I think once we get clarity on that, that will provide greater clarity as to the human lunar return portion and the viability of 2020 in terms of what we do and whether we can make 2020.

Mr. MCCAUL. I look forward to hearing about that. I am also concerned about our aerospace industry and their strength in the private sector, providing procurement for you that is cheaper and more competitive.

Lastly, this is a little bit outside the budget questioning, but I just read recently, I think in *Newsweek Magazine,* about cyber security with respect to NASA and about some of the intrusions that have taken place at NASA. As we know, to be competitive we have to have the upper hand and edge intellectual property wise with State secrets. How confident are you about the cyber security situation at NASA?

Mr. SCOLESE. Well, we have had intrusions as has been reported, and of course, we don't really talk too much about our security and how we caught those and whether they actually took any information of significance.

But we are constantly vigilant about it, and we work with our other government agencies on this because the threat is constantly evolving, and we have to be very careful about that. We have, in fact, strengthened our cyber security. We have created a security center out of the Ames Research Center to go off and monitor all of our computer activities, and at the same time, of course, with NASA we also have to provide resources to the public. That is part of what NASA does.

So while having an open system, we also have to have a system that is protected so that we don't lose vital secrets and more importantly we don't lose our assets on—in space because we control them all from the ground, and we use computers with it.

So I think it is—we do have an investment, we do recognize that it is an ever-evolving threat, and we are working with our other government agencies to identify that threat and to adapt and adjust, and it is taking resources to go off and do that.

Mr. MCCAUL. I know the President is planning to launch a new cyber security initiative which hopefully will strengthen these as-

sets, because I think the ones at NASA are perhaps the most valuable assets that we have.

So thank you so much.

Mr. SCOLESE. Thank you.

Ms. GIFFORDS. Thank you, Mr. McCaul.

Mr. Luján.

Mr. LUJÁN. Thank you very much, Madam Chairwoman.

NASA'S EDUCATION EFFORTS

Mr. Scolese, I want to drill down a little bit into the educational component, commitment that NASA has. New Mexico's universities benefit most from the education programs through the science budget specifically, which shows an increase of approximately $500 million between now and 2014.

Can you just discuss briefly the plans that NASA has with how they plan to expend those educational opportunities, with their university system in that specific regard?

Mr. SCOLESE. The—from the science side, our science mission directorate and our science missions, of course, play directly into it through providing opportunities for graduate students and for, you know, improving the tax as we, as professors are involved in it and what have you. And also in providing opportunities for them to build experiments. We have a number of opportunities. We have sounding rockets and balloon experiments where oftentimes students with their professors will go off and propose an experiment, develop it, fly it, all within three years so they get the experience of designing and developing an experiment, building the experiment, flying the experiment, analyzing the data, all within the timeframe that it takes to get a degree.

The—as we get to the bigger missions, of course, we try and do competitive missions where universities are engaged in those missions, and they are longer term, so they may be, you know, five or ten years and longer if you are going to someplace like Jupiter or Saturn where the transit time is considerably longer. So we have those types of activities.

In addition we have the direct educations activities where we work in partnerships with universities to get grants for students and for professors to conduct work, and we can get you more information on all of those, but that is sort of a summary of it at the very top level.

Mr. LUJÁN. Madam Chairwoman, thank you very much. Mr. Scolese, the area where I had a concern, and although I saw an increase in the budget in the science portion of this with the projected decrease in the educational component, of which I believe there is a program called MUST, Motivating Undergraduates in Science and Technology, which is funded by NASA in a joint partnership currently between the Hispanic College Fund, the United Negro College Fund, special programs in the Society for Hispanic Professional Engineers, which is a competitive program to be able to offer opportunities open to all children but targeted in each of these specific areas. Is there a commitment from NASA that this program specifically will not be reduced? Is there something that we can do to help ensure that this program will remain at the same levels, if not strengthen them, acknowledging that we do

need to make sure that we are providing opportunities especially educational opportunities for students to get into these fields so we can continue to provide NASA the support that they need?

Mr. SCOLESE. Those are all—that is very important. I am—I would have to go off and look to see if it is being reduced. MUST is one of the activities that we do definitely support, and it is one of our critical activities in the education enterprise. I will have to go off and look and see if there is any reduction to it in the future years, but that is not the intent.

Mr. LUJÁN. Thank you, and lastly, Mr. Scolese, New Mexico is home to White Sands Missile Range. Just if you could briefly discuss what the future plans and support that we should expect in New Mexico for White Sands through NASA.

Mr. SCOLESE. Well, we see a continued need for White Sands. In fact, later this year we are going to have the first test of our abort system for the Orion Ares stack. It is called Cad Abort I, and it is scheduled for this fall. So—fall or winter timeframe depending on when all the hardware arrives. So we are going to continue to do testing out of White Sands, and it will be a little bit different because we—as the Shuttle moves off, we will have some different components there, but we still need White Sands to do some of our testing. So it will continue to be an active system, and of course, we have the communications for TDRS are located there as well, and that will continue to be there for the foreseeable future.

Mr. LUJÁN. Thank you, Mr. Scolese.

Madam Chairwoman, I yield back my time. Thank you.

Ms. GIFFORDS. Thank you, Mr. Luján.

Mr. Rohrabacher.

CLIMATE CHANGE AND ASTEROIDS

Mr. ROHRABACHER. Thank you very much, and appreciate the fact that you folks at NASA do not now have the leadership to be making major policy directions decisions and even to be advocating new policy directions, but I am disappointed in one aspect of what your budget seems to reflect, and that is that with all the, you know, we have here certainly ample spending by NASA to yet again prove global warming. Okay. That is fine. Those of us who believe it is solar activity and chart all these changes in the world's temperature with the Sun. Okay. Forget us but let us keep spending money to prove that people are changing the climate.

But spending all of that money but yet we can't spend money on something that absolutely—we know is a potential threat to this world. I mean, we are totally ignoring, while we are looking over here at global warming, which more and more scientists every day are saying, no, it is solar activity, it is not human activity, but everybody knows there are objects out in space that could well hit this planet and causes tens of thousands, hundreds of thousands, millions of lives to be lost.

In March Asteroid DD–45 came within 38,000 miles of our planet, was not detected until it went by, and had that object hit this Earth, we would—it could well have caused hundreds of thousands of people to lose their lives, maybe millions. What is it, Apophis?

Mr. SCOLESE. Uh-huh.

Mr. ROHRABACHER. There is an asteroid that we know could do incredible damage to this planet, maybe not destroy all life on the planet but kills millions of people. It is going to come around in 2029, but the people that we have talked to have told us that we won't know until it comes through that time whether or not it might come back to the second time in 2036, and then be on a course to hit the Earth.

I do not understand that—why we cannot put at least a little money into trying to mitigate this real threat that is out there, but we don't have, we haven't identified exactly what it is yet. I mean, there is no money, correct me if I am wrong, there isn't even a couple million dollars to keep the Arecibo Telescope going in this budget. We got all this money to study global warming, which as I say, which most, a lot of us believe solar activity is responsible for, but nothing, not even a couple million dollars for the Arecibo Telescope, which is essential to tracking some object far enough away so that we might be able to do something about it.

Mr. SCOLESE. Well, let me try and address parts of those. I have——

Mr. ROHRABACHER. Okay.

Mr. SCOLESE.—some good news on the near-Earth asteroids. We were asked awhile back to go off and catalog 90 percent of the one kilometer or larger asteroids.

Mr. ROHRABACHER. Yeah. You are looking at the guy who asked you to do that.

Mr. SCOLESE. I know that.

Mr. ROHRABACHER. I am the Chairman of that committee.

Mr. SCOLESE. I know. That is why I thought I would mention——

Mr. ROHRABACHER. You did a good job at 90 percent of them.

Mr. SCOLESE. And we are going to finish earlier as a matter of fact. We believe that we will have accomplished that goal by next year in working with partnerships with other organizations, and as far as Arecibo, you know, we worked in partnership with the Air Force and with NSF. Arecibo is I believe in the NSF budget, so I wouldn't—we didn't have anything in the NASA budget on that.

So we haven't ignored the near-Earth asteroids or near-Earth objects, and we are working it, and as I said, I think we have made some good progress over the last couple of years, and we will address the one kilometer or larger earlier than we thought, and we are starting to look at the smaller ones now.

Mr. ROHRABACHER. Well, there is ample evidence that these—about every year now something comes through and we miss it, and if it would have been just like one degree different trajectory, it could end up creating a tidal wave off of my district in southern California. And being a surfer that might be good for one wave. It might not be after that.

RUSSIAN COOPERATION

One—and then over to space transportation. The—we are going to be spending more and more money with the Russians, and I think we ought to thank our lucky stars that the Russians are even willing the way we have been treating them diplomatically for the last 10 years, treating them as if they are the enemy, we are lucky they are even willing to do it. But aren't there some people in the

private sector that we might be able to give contracts to for some of the space station missions that the Russians are going to help us with?

Mr. SCOLESE. Well, we are on the cargo portion. We definitely are. We have signed two contracts this past year for cargo supply to the Space Station, and we are relying on that. In this budget request or operating plan request with the stimulus funds, we are looking to stimulate interest in commercial crew to the Space Station.

Mr. ROHRABACHER. Yeah, because we are going to spend a billion point two with the Russians for transporting our people up there. It seems to me that that would be a mighty strong incentive for some of our private sector people to develop an alternative that might go up on things like the Atlas V or other rockets that we already have.

Mr. SCOLESE. Yes, sir.

Mr. ROHRABACHER. Okay. Well, thank you very much.

I yield back my time.

Ms. GIFFORDS. Thank you, Mr. Rohrabacher.

Mr. Grayson.

Mr. GRAYSON. Thank you.

SHUTTLE PROGRAM FUTURE

Mr. Scolese, what options have you given to the White House concerning extending the Shuttle Program?

Mr. SCOLESE. I am sorry. Can you——

Mr. GRAYSON. What options have you given to the White House concerning extending the Shuttle Program?

Mr. SCOLESE. We have not been asked for options to extend the Shuttle Program.

Mr. GRAYSON. Have you offered any?

Mr. SCOLESE. No.

Mr. GRAYSON. Well, I understand that there are pros and cons in favor of and against extending the Shuttle Program. Can you lay out for us some of the pros?

Mr. SCOLESE. Well, we would keep on flying the Shuttle. It would provide us some opportunities clearly to keep the Station re-supplied and obviously the jobs in the various districts that are impacted by the Shuttle. However, the concern, of course, is that a lot of those people who are working on Shuttle are also working on Constellation, and that would take them away from working those programs, plus without additional resources we would be taking funds away from developing the Next Generation System so we would just be moving the gap out as opposed to resolving the gap.

The other aspect of the Shuttle, of course, is it doesn't relieve us of our dependence on Soyuz or any other system because we can't do crew rescue with the Shuttle. It cannot stay on orbit for longer than a few weeks based on its design. So we would still have to have a Soyuz attached to the Station or some other vehicle attached to the Station for the duration that the crew is there if they had to escape.

So those are the reasons that we haven't in the course provided that. Even if we were to start up today to do it, though, we still have, would have to restart some lines, the external tank and the

solid rocket motors in particular. It would be about three years before you could get another external tank if we start it today.

So there is—there would still be a gap in the program along those lines.

Mr. GRAYSON. If the White House asked you to figure out a way to extend the program for a certain period of time, what would you recommend to them about how to do that?

Mr. SCOLESE. We would have to, you know, ask for more budget, I guess, would be the answer. Or we would have to delay the Constellation Program. Those would be the only real things we could do.

Mr. GRAYSON. Now, you said you were moving employees from one program to the other, but you—in your testimony you have a projection that there is 6,400 contractor employees in one fiscal year and 1,600 in the next. So that is a 4,800 contractor employee drop. Those people aren't going to be working on Constellation. Right?

Mr. SCOLESE. We don't know. I mean, when it comes to the contractors, it is a little bit more difficult for us to say because the contractors do the work assignments on those, and it depends, of course, on what work those people get. We make our projections based on when we stop doing this work, this is how many people will leave on the contractor side and then if they win work, those same people may be brought back to do other jobs.

So we have a hard time telling you what the actual net impact will be given our understanding of where contracts are going to be awarded and where they are not.

Mr. GRAYSON. Have you had any discussions with the White House concerning spacing out the remaining launches?

Mr. SCOLESE. We have recently changed, if you noticed, the wording based on discussions that have occurred to say that we intend to fly out the remaining manifest, and we have not put a date on it. Now, we believe we can fly out that manifest by September of next year, but the requirement now is that we will fly out the remaining eight missions without a date specific.

Mr. GRAYSON. What would be some of the benefits of expanding that timetable, spacing out the missions more broadly?

Mr. SCOLESE. Well, again, it comes down to budget. We do not have the resources to go beyond 2010, beyond September, 2010, so it is going to require additional resources that will have to either be added to the NASA budget or have to be removed from other portions of the budget with, you know, impact to those portions of the budget.

BENEFITS OF NASA

Mr. GRAYSON. Let me ask you a different kind of question. People often ask what is the benefit of this program, what is the benefit of NASA in general to our society, and I think that we Members of this panel have an answer to that, but I wanted to ask you looking forward, looking into the future, and I understand as Yogi Berra said, "Predictions are hard to make, particularly about the future," looking into the future, what kind of scientific discoveries do you see being possible through NASA's work? I guess one place

to start would be the discovery of life on other planets, on Mars, on Europa perhaps. That is one.

Tell us what other possible scientific discoveries you see from NASA's work.

Mr. SCOLESE. Well, that is a difficult one to answer, as you said. Clearly, you know, one of the things that we look for is the search for life that would have some significant changes to what we do, and we look out in the universe already we have seen some, you know, incredible changes that we didn't expect. We found water almost everywhere we looked. You mentioned Mars, you mentioned Europa. We also found it in Enceladus at Titan, I mean, at Saturn. We have discovered planets outside of our solar system, something that was, you know, science fiction just 20 years ago. Finding a planet that is similar to Earth will be, you know, a possibly as we develop the missions to go off and do that. Kepler has recently been launched and is going to go off and start cataloging, not observing, the sizes of planets near our solar system, if you will.

Looking more down to Earth, our missions are going off and helping us to better understand the Earth, better predictions of weather, better predictions of climate will help markedly on the Earth as we come up with better agricultural predictions, as we develop, you know, a better understanding of where hurricanes will go, we can do more with natural disasters, already looking at ways to mitigate the impacts of volcanic activity by understanding the flows of volcanoes and identifying escape routes using satellites, fire mitigation to go off and support that. Using orbital assets plus UAVs that NASA has gone off and developed.

Chairman GORDON. Excuse me. With respect to Mr. Grayson, as well as you, Mr. Scolese, we only have two days. There are many, many benefits of NASA, and I think we could catalog those for quite some time.

Mr. GRAYSON. Great. Thank you.

Chairman GORDON. And the gentleman's time is well over. So with—if there is no objection, we will then yield to Mr. Ehlers for five minutes.

Mr. GRAYSON. Thank you, Mr. Chairman.

Mr. EHLERS. Thank you. As I commented earlier, we are still waiting for more of those benefits to come to Michigan, which is in worse shape than any other state. That is not my question.

AERONAUTICS

My question is NASA is National Aeronautics and Space Agency. All the discussion here has been about space. I really worry about aeronautics at NASA. You have some outstanding people there, and I have been very impressed with them in a number of ways. We desperately need their help, which means you need more money as we go into NextGen. I respect the FAA and their research efforts, but I also recognize the unique capabilities you have at NASA, and I am not asking you to solve this overnight, but I am very concerned about NASA being able to fulfill what should be required of it, the NextGen, and frankly, in a lot of other aeronautical areas. As you know, we have a huge battle for market share between our aeronautics manufacturers, our various plane

manufacturers, and Europe, and the Chinese are now beginning to manufacture airplanes.

So I don't want you to go at great length on this, but I would very much appreciate some comments from you about the future direction you see for the aeronautics and where the Congress should put more money in view of the problems I outlined. These are not immediate problems, but they are pressing problems, and we are going to be very sorry if we don't provide adequate support for the aeronautics part of NASA, because it is going to come back and bite us in the next five or ten years.

So I would appreciate your comments on that.

Mr. SCOLESE. Yes, sir. I think it is probably worth just mentioning the new program that we have in the Agency, the Environmentally Responsible Aviation Program, which is going off and working to develop more efficient utilization of the air space, more efficient aircraft operation, and working on the technologies both to make those systems more efficient but also working to understand with our colleagues in the FAA and others to make the airspace system more efficient.

So it is more than just making an aircraft better or making the air traffic control system better but to make the whole system improved. That is a new initiative in this budget that is proposed in fiscal year 2010. We have—it builds upon all of our other activities in fundamental aviation and other areas, so I think that is a new area that goes off and recognizes the needs for the future, to have more fuel efficient air system, to have a safer air system, and those are the types of things that we will be working on in that activity.

Mr. EHLERS. And how much new money are you getting for this new endeavor?

Mr. SCOLESE. I would have to look exactly, but I believe it is in the order or—maybe David you can give me the exact number. We have $60 million in fiscal year 2010 to start that program off.

Mr. EHLERS. Okay. I hope you get considerably more than that because I think the need is really there, and it is not just for NASA, and it is not just for science. It is—I think it is a major item for our country as well.

With that I thank the gentleman.

Chairman GORDON. Thank you, and Ms. Kosmas from Florida is recognized.

NASA WORKFORCE DURING GAP

Ms. KOSMAS. Thank you, Mr. Chairman. Thank you, Mr. Scolese for being here. I, too, appreciate your service, and I would echo the comments of my colleague, Dr. Griffith about the importance of this and during my short time here I have tried to be very vocal and my expressions for my respect and passion for the Manned Space Program.

And I wanted to ask some questions that have already been asked. I won't re-ask but specifically because, as you know, Kennedy Space Center is in my district, and I represent the workforce there. I am most concerned about the gap in terms of the workforce. During the time period that we have suggested that we intend to procure up to 24 seats per astronauts on the Russian Soyuz, is there an alternative for us during that time period where

we would not be—and I think according to *Aviation Week*, the price has risen to $51 million per seat for 2012. This means, as was earlier suggested, $1.2 billion creating jobs for Russians as opposed to in the United States.

Has there been an alternative discussed between you and the Administration with regard to how we might keep that revenue source inside our borders?

Mr. SCOLESE. Well, with the current plan there is no alternative to doing it. As I mentioned earlier, we need the Soyuz not just for getting the crews to the Space Station or back from the Space Station, we need the Soyuz for crew rescue as well. So we need it to stay on orbit, and we don't have any other vehicle that—at this stage that can do that.

I am certain this is going to be addressed as part of the review that is going on this summer, but at this stage of the game the Soyuz is really the only opportunity that we have that can address all three of those things; taking the crew to the Space Station, returning the crew from the Space Station, and serving as a rescue vehicle in the event that we need to remove crew from the Station for any reason.

Ms. KOSMAS. Okay. Thank you. I appreciate also the commitment to finishing the Shuttle manifest and removing the hard deadline for having that occur, because I think that is very important for the safety of the program.

But given the fact that we are going to have a gap between the Shuttle Program and the Constellation or whatever comes next, I assume according to our discussion you are continuing not slowing down anything on that front, how do we intend to keep our astronauts engaged, or I understand we are getting ready to select a new class of astronauts. And how do we intend to make that work during the time, keep our core engaged or attract new ones during that time period?

Mr. SCOLESE. Well, of course, we will still be flying the Space Station, we will still be going to the Space Station, so there will still be crew there, and we will need our astronauts to train for that and fly to that. So we will continue to need that core. In addition, as we are building and testing the new vehicle, we will need the astronauts to be intimately involved with the design and test of that vehicle.

So there will be still be ample opportunities and ample jobs for the astronauts both on the Space Station and in developing the new hardware as we get ready to—and as we get ready to fly it.

Ms. KOSMAS. Thank you. The only other question I had at the moment is with regard to the workforce at the Kennedy Space Center. We have heard the numbers projected of what I think will be the loss of a very big number of professional folks during that gap, and what I am wondering is that Kennedy Space Center has been viewed as an operations center only, and there is much discussion in my District and among others about the opportunities to increase the amount of research and development that would go on at Kennedy Space Center, particularly perhaps with regard to the Constellation and the—all that goes along with that.

In fact, former Administrator Griffin stated last year that the work on the Altair Lunar Lander would be conducted at KSC, and

I am wondering whether you have had any further discussion about that in particular.

Mr. SCOLESE. I think we are continuing to do things at Kennedy Space Center, and of course, it has been operations in the past several years, but as you know, we are doing a lot of development there right now as we are developing the launch pads and the control centers for the new vehicle. So there is development going on there. I am sure you are also aware that they are going to do manufacturing of Orion there, manufacture and test of it. So we do have development work that does go on there, plus, you know, some research work as well.

So I think there is no change in that in seeing that development go on.

Ms. KOSMAS. I think we are looking to expand the operations there so that we are not so vulnerable to the gap and other time periods that have taken place historically where we have a shutdown in our community.

So I would appreciate that consideration during the review——

Mr. SCOLESE. Will do.

Ms. KOSMAS.—that is coming up. Thank you very much.

Chairman GORDON. Okay. Thank you, Ms. Kosmas.

And Ms. Brooks is recognized for five—I mean, Ms. Edwards is recognized for five minutes.

Ms. EDWARDS. Thank you, Mr. Chairman, and thank you very much, Mr. Scolese, for your testimony.

CURRENT NASA BUDGET INCREASE

I just have a couple of questions about—and I put this to Mr. Holdren when we heard from him, I guess last week, and it has to do with the budget. We have, you know, we have a goal out there of going back to the Moon, we have a goal of this Next Generation of exploration, technology, and vehicles, but it just seems to me that the budget is not quite reflecting that goal.

And so I wonder if you could, apart from the funding that we just put into the Recovery Act, which was, you know, a substantial $630 million for the—for fiscal year 2009 and 2010, how critical are the activities that are going to be conducted with this increase, and then discuss for me the budget as you see it for the future as it impacts areas in Orion. And I am wondering if there might be an unanticipated risk by essentially putting on hold the budget decisions in the out years on our ability to retain capacity, technical, scientific, and research capacity for those and other programs.

Mr. SCOLESE. The $630 million additional that fiscal year 2009 and 2010 budget is absolutely critical to maintaining the Ares and Orion programs. The early years, '09, '10, '11, '12, essentially, are really focused on getting the first systems, the Orion and the Ares I and the associated ground systems and control systems ready. So that funding is critical to keeping us on what we call initial operational capability, the ability to get into low-Earth orbit, to get to the Space Station, and that capability is also needed in the future for when we do want to leave Earth orbit to rendezvous and dock with the vehicle that will take us beyond low-Earth orbit, to the Moon or wherever.

So the first few years are absolutely critical to keep that in for initial operational capacity. We were doing less on Ares V and the landing systems in those years, so the out-year budgets in '13 and '14, principally, would have an impact on those. So as this review gets done, we will have time to understand, you know, what we want to accomplish by 2020 that will help determine what we need out there in those years.

In addition, the heavy-lift launch vehicle is absolutely critical to getting out of low-Earth orbit. That was mentioned earlier, the Ares V. It has common elements with Ares I, which allows for the development that is going on today to be directly applicable to the Ares V. So the development on the solid rocket motor and development of the J–2X engine are directly applicable to the Ares V. So work we are doing today also plays into what is going to happen in 2013, and '14.

Ms. EDWARDS. Do you worry at all about the loss, potential loss of technical capacity at all?

Mr. SCOLESE. I don't think we have that issue for the immediate future. As I was saying, we are concentrating right now in the next couple of years on the initial operational capability. So of course we always worry about it. You want to make sure that people understand that there is a future out there so they stay, but I think we have sufficient interesting work and sufficient work altogether that that won't be an issue for a few years.

Ms. EDWARDS. And related to that are you concerned at all that we have this couple of months that we are waiting for the review to take place but we are on a, you know, track to look at the budget, and you know, we maybe, in fact, putting the heart—the cart before the horse in terms of, you know, scaling back in some ways on those out-year budgets without actually understanding what the review holds for us.

Mr. SCOLESE. Well, if—as I said, any change in '09 and '10, or '10 budget will have a significant impact on the program. So—and specifically we were directed not to change anything until the review—we, NASA, not to change anything, to continue working with—on Ares I and Orion and all their elements until told to do otherwise, and we haven't been told to do otherwise, so we do need that '10 funding if we are going to stay on that track. Otherwise there will be impacts along the lines of what you are talking about to the workforce as well as to our ability to meet the mission goals.

ORBITING CARBON OBSERVATORY

Ms. EDWARDS. I just have one additional question, and it is related to the Orbiting Carbon Observatory that was lost in February, 2009. Any plans to replace that? I noticed it is not in the budget.

Mr. SCOLESE. It is not in the budget. We are off reviewing how to go off and do that, so we didn't have a plan. Three parts to it. One, we don't plan for losses, so we have a review with science community and the operational community the value of that mission, and it was determined to be a valuable mission. So we are off evaluating two options for re-flying it. We hope to have that done by the end of the summer, and we will be able to get back to you at that point.

Chairman GORDON. Thank you, Ms. Edwards. They are good questions, and Mr. Hall has some clean up he wants to do.

WORKFORCE AND FUNDING GAP

Mr. HALL. First, I was a little astounded at your answer that you didn't think it was any big problem when we lose that workforce. Did I misunderstand you?

Mr. SCOLESE. I don't think I said that, sir.

Mr. HALL. Okay. Well, I hope you didn't.

Mr. SCOLESE. No, I didn't.

Mr. HALL. Because they are an exclusive group and the highest type of workforce and sophisticated, and they would be quickly picked up by someone else, and if we wait two years or four years, we are going to have a hard time finding the people to take those places, I think. Don't you—you agree to that?

Mr. SCOLESE. Oh, absolutely. We have one of the most highly-motivated workforce and the most capable workforce there is, but I thought I said, what I intended to say was I felt that we had sufficient work and sufficiently-interesting work to retain that workforce.

Mr. HALL. Well, good. That is great. I want to just talk a minute—I mentioned and talked about funds and about the gap, four-year gap, and it is going to take money and time, and we were worrying a little bit about the deficit, but I think there are some answers to that. We seem to spend billions of dollars every year on foreign assistance, you know, all over the world, and I sometimes wonder what we are getting out of that, and who knows where, when, or how this money is spent. I know that we sent money—we use part of NASA's budget to purchase services from our international partners on International Space Station, and I have wondered why some tiny fraction of the billions of dollars that the government spends on foreign assistance couldn't be transferred to NASA like a lot of countries that vote 80 to 90 percent of the time in the U.N. against this country that were receiving foreign aid. I think we ought to take a look at that, and that would be one place—I think it is our duty to point out where that money can come from if we are willing to up the budget of NASA, and I think that ought to be not too tough to do.

Do you think the blue ribbon panel that is going to be chaired by Mr. Augustine would have the freedom to suggest or propose alterative funding options and from elsewhere within the federal budget to help reduce the gap? I know they are not going to want him to bust the budget or go outside that, but I don't believe he is the type guy you can give some parameters to and tell him he has got to stay within those. I think he is going to tell you what he really and truly thinks, and that is the reason that most everybody I know is very proud that we have him leading us to help reduce the gap and better meet our international obligations.

It looks like we could use some of those sources. You don't have any problem with that, do you?

Mr. SCOLESE. No, sir.

Mr. HALL. I like you. I like the Chairman here, too. I like him so much I am going to yield back my time.

Chairman GORDON. Thank you, Mr. Hall. We have, in effect, opened the second round, so Ms. Kosmas or Ms. Edwards, do you have a second question?

Okay. Mr. Olson, you can close us out then.

U.S. SPACE INDUSTRIAL BASE

Mr. OLSON. Thank you very much, Mr. Chairman, and I have just a very brief question for you, Mr. Scolese, involving our—concerning the industrial base, and as the Acting Administrator, you have got a pretty broad view of all of NASA's programs and some insights into other governmental programs.

What is your assessment of the U.S. Space Industrial Base and how might NASA and Congress improve the situation to make our aerospace industry stronger and our procurements cheaper?

Mr. SCOLESE. That is—you are right. That is a very broad question. It is—I think we mentioned earlier that with some of the restrictions that happen with the ITAR that it limits our industry from being able to compete overseas, there is other portions of the activity as well. We aren't launching as many missions, we aren't doing as many things in this country that we have done in the past. So we have had a lot of consolidations within industry.

The instrument industry is probably an area that is the easiest to go off and look at recently where we are seeing some significant impacts into our missions because the instruments are coming, you know, very, very late, and part of the reason is what we were talking about before. We consolidated so much that we lost a lot of the really high-value talent. They have gone off to do other things, and excuse me, and that has caused us to have to reinvent the wheel every time we go off and start a new activity, and we don't have enough new activities to keep any one organization sufficiently busy that they can carry the workforce through all of, you know, effectively from one development to the next.

And that seems to be general throughout the industry. So it is something we need to address. In addition, we have stepped back from specs and standards that we used to have in the early '90s, and while at times they were constraining and prevented us from doing things, they also allowed us to go off and have a capability that we could draw on when we needed it.

So today we often talk about why our spacecraft cost so much, we have to go off and understand our part suppliers, what kind of a part are we getting. Do we either invest in developing a new part, which isn't going to have very much statistics associated with it, so we have to do a lot of testing, or do we go off and get a commercial part and up-screen it, which requires a lot of testing until we find a part that we can use.

So we have done a number of things in terms of stepping back from specs and standards, reducing the number of activities that we have going on so that we are losing some of our workforce, and of course, the pipelines. I think you have heard, and I don't need to report, to repeat the statistics here, how the United States isn't putting out as many scientists and engineers as many other countries are, so, you know, putting in the pipeline to go off and fill those jobs is equally difficult.

So those are the things that we have going on, and they do have an impact into where we are going, but what can we do about it is probably a question that you want to ask, and I think what we need and what we are working, we are working with our partners in the Department of Defense and in industry and academia to form a partnership so that we can take various elements of it and effectively utilize it to put the resources where we can maintain them over the long term, which is one reason why the NASA infrastructure is important, to do the R&D that needs to be done and NASA, being an R&D agency, is an ideal place to do that. There is others as well, NSF and NIST as examples that do R&D, and working with our industrial partners where they can do what they do best, which is manufacturing and manufacturing technologies.

So we are trying to work together with, as I said, with our colleagues in industry and academia and other government agencies to try and bring that together and bring to you solutions that are in our budgets to maintain our infrastructure, to maintain the research and development and to encourage the educational system to produce more science and technology people.

Mr. OLSON. Well, thank you for that answer, and I have one comment to make, and it is probably not going to be a surprise to you, but I just want to assure you and everybody within the sound of my voice that NASA still has our Manned Space Flight Program, still has the ability to inspire America's youth.

Mr. SCOLESE. Absolutely.

Mr. OLSON. I had the privilege to watch the launch Monday before last with the entire 3rd grade at Settlers Way Elementary School in Sugar Land, Texas, about 50 or 60 of them, and we started watching about 20 minutes before the launch, and those kids were on me for all 20 minutes, I mean, hands up, hands up, hands up, asking about the solid rocket boosters, what happens when they land and how come they don't hit ships, you know, all the questions, I mean, great questions for third graders. We got down to 25 seconds and the countdown. As kids would do, they all just started counting down at the top of their lungs, but as soon as those main engines started firing and that solid rocket boosters came on, and she pulled away from the pad, they went silent and just stared. It was a great, great moment, and that is why what we are doing here is so important.

Mr. Chairman, I apologize for running over. I yield back.

Chairman GORDON. That is all right, Mr. Olson. Thank you for your presence here today and good questions.

Mr. HALL. Mr. Chairman.

Chairman GORDON. Yes, sir, Mr. Hall.

Mr. HALL. I just thought of two other places. You know, the $40 billion George Bush hollered back over his shoulder when he was leaving, that he wanted for AIDS for, I think Africa. Give them $30 billion and there is $10 billion that we have, and the Obama asked for buckets full more than $40 billion and just—I think the money ought to—we ought to rob those that don't deserve it, and we absolutely have to do something about that four-year gap.

You will be a magician if you can do it, but there are some places it can come from, and I won't ask to be recognized anymore today.

Chairman GORDON. Don't you own a bank?

Well, there has been a lot of discussion today about the quality and expertise of the NASA workforce, and Mr. Scolese, as I said at the beginning, you have exemplified that during this hearing that you are a representative of that, and we thank you for your service, we thank you for being here.

And the record now will remain open for two weeks for additional statements from the Members and for answers to any of the follow-up questions the Committee may ask of the witnesses.

The Chairman—the witness is excused, and the hearing is adjourned. Thank you.

[Whereupon, at 4:10 p.m., the Committee was adjourned.]

Appendix:

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Christopher J. Scolese, Acting Administrator, National Aeronautics and Space Administration (NASA)

Questions submitted by Chairman Bart Gordon

Q1. NASA's FY 2010 request provides $458 million more funding for NASA's Exploration program than was provided in the FY 2009 Omnibus. At the same time, the Administration is carrying out an independent review of NASA's human space flight programs this summer that could result in changes to NASA's Exploration program. Congress is going to be working on NASA's FY 2010 appropriations in the relatively near future.

a. For the record, why do you need increased funding for Constellation at the same time that the program is under review?

b. Specifically, how important is it for Congress to fully fund Constellation, including reserves, for FY 2010?

c. What would be the impact of a cut to your FY 2010 Exploration budget request?

d. If Congress is being asked to fully fund the Administration's budget request for NASA's exploration program in FY 2010, what assurances can you give this committee that the Administration is committed to continuing work on the Exploration program's Constellation projects as planned during the review and will not divert funding from them or slow them down?

A1. As NASA and the Administration review findings of the Augustine Commission in the coming weeks and formulate an Administration recommendation for submission to Congress on the way forward for human space exploration, it is important that the President's FY 2010 request for Exploration be fully funded and flexibility be fully preserved. Any reductions would likely cause major negative impacts to any options that may emerge from the ongoing blue ribbon review of U.S. human space flight plans.

Following the Review of U.S. Human Space Flight activities, the Administration will provide an updated request for Exploration activities, as necessary. In the meantime, NASA is proceeding with current Exploration activities, including Ares I, Orion, Commercial Crew and Cargo efforts, and lunar systems. For example, NASA is continuing to work toward completing two major test flights this year. The Ares I–X was the first developmental test flight to support the design of the Ares I Crew Launch Vehicle; and the Pad Abort 1 (PA–1) will be the first test of the Launch Abort System to be used on the Orion Crew Exploration Vehicle. NASA will continue to work with other nations and the commercial sector to coordinate planning, leverage investment, and identify opportunities for specific collaboration on Exploration activities.

Q2. NASA's Earth science program received an increase of over $1.2 billion when taking into account Recovery Act funds and FY 2010 budget projections through FY 2013.

Q2a. To what extent is this increase going to enable progress on the Earth science missions recommended in the National Academies decadal survey report?

A2a. The funds will enable NASA Earth Science to make marked progress toward conducting the balanced program recommended by the National Research Council's decadal survey in Earth science, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*. Following the Decadal Survey framework, the funds will enable NASA Earth Science to:

- Complete as rapidly as possible the foundational missions that are currently in development (Aquarius, Global Precipitation Measurement (GPM), Glory, Landsat Data Continuity Mission (LRCM), and the NPOESS Preparatory Project (NPP)). The Decadal Survey recommendations for new missions were predicated on the assumption that these foundational missions would be completed and flown in advance of the new missions.
- Establish Earth Venture (EV) as a new element within the Earth System Science Pathfinder (ESSP) Program. The additional Earth Science funding enabled NASA to issue in July 2009 a solicitation of proposals for the first group of Earth Venture (EV–1) missions.
    - Earth Venture consists of a series of regularly solicited, competitively selected Earth Science investigations. Earth Venture will provide competi-

tive opportunities on two-year intervals with ~$150M per solicitation. Opportunities will alternate between integrated sub-orbital investigations, instruments of opportunity and small satellites.

- The EV–1 solicitation is for complete sub-orbital science investigations involving sustained data acquisition from airborne (aircraft and/or unattended airborne system (UAS)) and/or balloon platforms. Each sub-orbital Venture-class investigation will have a life cycle of up to five years and a total investigation cost of up to $30M; several investigations will be selected depending upon the cost of each.

- Accelerate progress on the new missions recommended by the Decadal Survey, including the Tier 1 missions: the Soil Moisture and Active Passive (SMAP) mission, the Ice, Cloud, and land Elevation Satellite–2 (ICESat–2) mission, the Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission, and the Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) mission.
- Initiate in FY 2009 the IceBridge airborne field campaign series in both the Arctic and the Antarctic to mitigate the gap in observations of the polar ice caps that will occur between the end of ICESat–1 and start of ICESat–2. IceBridge uses various NASA aircraft and instruments to characterize key areas of polar ice, including the diminishing Arctic sea ice cap and rapidly changing outlet glaciers in Greenland and Antarctica. The mission is planned to run until the launch of ICESat–2.
- Maintain a balanced program of satellite and sub-orbital observations, research and analysis studies, and societal application activities lauded by the Decadal Survey, including:
  - 15 operating missions that provide the world with a primary source of observations and science information on Earth's changing environment
  - A suite of aircraft and Unmanned Aircraft Systems (UAS) with scientific instruments to fly at 100 feet (30m) to 70,000 feet (21,000m) that will ensure high accuracy, well calibrated observations from satellites and enhance interpretation of satellite data
  - Internationally recognized state-of-the-art climate models
  - The world's largest scientific data and information system for collecting, processing, archiving, and distributing Earth system data to worldwide users
  - Practicable applications of observations and results for informed decision-making
  - Technology development investments for Tier–2 and –3 missions.

The funds will enable the flight of a Thermal Infrared Sensor (TIRS) instrument on the Landsat Data Continuity Mission (LDCM), one of the foundational missions referenced by the Decadal Survey.

Q2b. How much acceleration on those missions is this funding buying?

A2b. The funds will enable NASA Earth Science to progress from a period of declining budgets and the resultant reduction in satellite measurement capability, which the Decadal Survey raised as a serious concern, to carrying out its mission with improved overall capabilities. The funds allow NASA Earth Science to achieve many recommendations of the Decadal Survey, as noted in Answer 2, including the flight of the foundational missions.

The Decadal Survey, in recommending launch readiness intervals of 2010–2013, 2013–2016, and 2016–2020 for Tiers 1, 2 and 3, respectively, presumed a budget for NASA Earth Science of $2.013 per year (about 25 percent higher than its current budget) and lower mission costs than NASA estimates are projecting. All future missions identified by the Decadal Survey are extremely early in their definition process, thus there is no substantiated basis against which acceleration can be compared or quantified. With that caveat, Table 1 indicates the estimated schedule and content changes for missions presently in development enabled by the additional funds that have been identified for the program. It also references the ICEBridge airborne campaigns and Earth Venture solicitation made possible by available funds.

Table 1
Projected Schedule and Content Changes for Venture Class Investigations and Airborne Campaigns and Space Missions Presently in Development Enabled in the Earth Science Program
by Funding Increases Identified in FY 2009

	Without Funding Augmentation	With Funding Augmentation	Changes Due to Augmentation
Aquarius	FY 2010 Launch	FY 2011 Launch	Accommodated international partner's schedule delay.
Glory	FY 2011 Launch	FY 2011 Launch	Accommodated delays due to Taurus Launch Vehicle failure and technical issues.
NPP	FY 2011 Launch	FY 2011 Launch	Accommodated late instrument deliveries from NPOESS.
LDCM	FY 2014 Launch No TIRS Instrument	FY 2013 Launch Full TIRS Instrument	Launch 1 Year Earlier Full TIRS Instrument
GPM Core	FY 2014 Launch	FY 2013 Launch	Launch 1 Year Earlier
ICEBridge	None	Annual Flights	Enabled Annual Flights

Q2c. Based on what you have studied and know about what is required to develop the Decadal Survey missions recommended for implementation by NASA, what is the total level of investment that will be required? Over what period of time do you expect it will take to implement those missions?

A2c. For the Tier 1 missions (SMAP, ICESat–2, DESDynI, and CLARREO), NASA's current preliminary total estimate of life cycle cost (LCC) is $4.213. Based on the FY 2010 Budget the launch of SMAP, the only mission which has progressed to date into Formulation, is planned for 2015 and the estimated mission life cycle cost (LCC) is $700M. The launch of ICESat–2, which will enter formulation in FY 2010, is planned for 2015 based on the FY 2010 Budget and the estimated LCC is $750M. Timing decisions for the remaining Tier 1 missions, CLARREO and DESDynI, will be made in FY 2010, with the expectation of launching these missions before the end of the decade.

NASA Earth Science did generate a Rough Order of Magnitude (ROM) life cycle cost (LCC) estimate for each mission shortly after release of the Decadal Survey in order to provide an initial comparison with the Decadal Survey ROM estimates. The collective ROM LCC's for the Tier 2 (SWOT, HyspIRI, ACE, ASCENDS, and GEO–CAPE) and Tier 3 (LIST, PATH, GRACE–II, SCLP, GACM and 3D–Winds) missions were $4.5B and $4.0B in FY 2007 dollars, respectively, compared with Decadal Survey estimates of $2.5 billion for Tier 2 and $3.1 billion for Tier 3. The currently projected funding profile translates to launches of the Tier 2 and 3 missions during the 2020's and into the 2030's.

These estimates are ROMs because the concepts are preliminary. Developing a credible life cycle cost (LCC) is a challenge because it includes all design, development, verification, production, launch, operation and maintenance, and disposal costs. Because of the level of design maturity required to generate this information, NASA formally commits to LCC at KDP–C, following a Preliminary Design Review at the end of the Formulation phase. At that time, the work associated with Phase A and Phase B concept development studies is complete and NASA is able to establish a baseline mission concept and generate the associated LCC with a 70 percent confidence level.

To help plan for these missions and reduce future schedule and cost risk, NASA Earth Science is providing funding within the current budget for preliminary workshops to discuss requirements and concepts for individual Decadal Survey missions and investing in efforts designed to ensure the technological readiness of these missions.

Q3. The Mars Exploration Program has experienced great successes scientifically and technically with its lander, rover, and orbiter missions. The next Mars mission, the Mars Science Laboratory, has overrun its baseline estimate for development by 68 percent. What is the implication of this cost growth for the future Mars Exploration Program?

A3. The impact on future Mars Exploration Program missions is as follows:

- The Mars 2013 aeronomy mission Mars Atmosphere and Volatile Evolution (MAVEN) is unchanged.
- The Mars 2016 mission budget has been reduced; NASA is in negotiation for a joint mission with the European Space Agency (ESA), which had also been planning a mission in 2016 but is also cost-constrained.
- Mars technology funding from FY 2010 through 2015, targeted at long-lead investments for a Mars sample return mission, has been drastically reduced.

NASA is currently revising its Mars architecture for future missions, in an attempt to create a collaborative program with ESA, culminating in a joint Mars sample return mission late in the next decade—the National Academy's highest priority science mission for Mars.

Q4. The National Academies is in the process of carrying out three decadal surveys in the areas of astronomy and astrophysics, planetary science, and biological and physical sciences in space. The decadal surveys will recommend the priorities for mission activities to be conducted over the next decade.

Q4a. To what extent have the mission priorities from the previous decadal surveys been accomplished?

A4a. Taking each decadal survey area individually:

Astrophysics:

The 2001 National Academy of Sciences "Astronomy and Astrophysics for the New Millennium (AANM)" report provided its recommended new initiatives for astrophysics in three categories according to the amount of anticipated funding required: Major, Moderate and Small Initiatives (AANM, page 33). The report included initiatives for both ground- and space-based projects, and discussed the importance of program balance and basic research. The top priority Major Initiative for space was the Next Generation Space Telescope, which has since been named the James Webb Space Telescope (JWST). NASA is making substantial progress and JWST is under development having passed its confirmation review in July 2008 with a launch readiness date of June 2014. The top priority Moderate Initiative for space was the Gamma-ray Large Area Space Telescope, now renamed the Fermi Gamma-ray Space Telescope. Fermi was launched in June 2008 and is producing excellent data. The top priority Small Initiative was funding for the National Virtual Observatory, now called the Virtual Astronomical Observatory (VAO). NASA is coordinating the VAO funding with the National Science Foundation, which has recently announced the selection of the VAO provider.

For each of these categories there were numerous other activities recommended, but at lower priority. In the Major Initiatives category the second priority was the Constellation-X Observatory. Mission-level studies and early technology development activities have been accomplished throughout this decade. NASA was unable to start the mission because there were insufficient funds to begin development of the mission once its costs were better understood. The third priority was mission studies and technology development funding for a Terrestrial Planet Finder mission. NASA devoted the recommended level of funding to this activity and gained a better understanding of what such a mission would cost. These activities have positioned the community and NASA to provide the current decadal survey panels more accurate information on the technical challenges and likely costs for such. a mission. The final Major Initiative priority was for early study of and technology development for a large aperture sub-millimeter optimized space mission (SAFIR). Only a small amount of funding for a SAFIR mission-level study has been expended during this decade.

For Moderate Initiatives at lower priority than Fermi the NAS report listed the Laser Interferometry Space Antenna (LISA), Solar Dynamics Observatory (SDO), Energetic X-ray Imaging Survey Telescope (EXIST) and Advanced Radio Interferometry between Space and Earth (ARISE). For LISA, a collaborative mission with the European Space Agency, mission studies and technology development were funded throughout the decade. NASA was unable to start the mission because there were insufficient funds to begin development of the mission once its costs were better understood. The SDO satellite has completed development under the management of NASA's Heliophysics Division, and is awaiting launch in Fall 2009. NASA funded a mission-level study for EXIST. There were no mission-level activities for the ARISE activity this decade.

In the Small Initiative category lower priority activities included recommendations for augmented funding in various areas of basic research at NASA and for the Advanced Cosmic-ray Composition Experiment for the Space Station (ACCESS).

Agency policy decisions regarding usage and access to the International Space Station shifted the focus of cosmic-ray experiments to balloon borne payloads. NASA flew several such payloads during the decade. NASA has kept the level of funding for Theory and Laboratory astrophysics essentially constant throughout the decade despite several directed reductions in the broad area of research and analysis [out of which Theory and Laboratory astrophysics are funded]. The Astrophysics Division has recently augmented its funded postdoctoral programs to levels at or above those recommended in the decadal survey. Finally, this past year saw a successful test of the first Ultra-long Duration Balloon. NASA is now considering what payloads would be good candidates for this type of balloon platform.

The report also endorsed continuation of a vigorous Explorer program (page 9). Since the 2001 decadal survey, NASA has launched the GALEX and Swift missions, as well as the Kepler mission in March 2009 (the Kepler mission to search for Earth-sized planets was selected in the Planetary Science Division's Discovery Program, which like the Explorer Program is a line of competitively-selected Principal Investigator-led missions). The Wide-field Infrared Survey Explorer (WISE) is planned for launch this December, and the Nuclear Spectroscopic Telescope Array (NuSTAR) is being developed for launch in 2011.

In addition to these new initiatives the AANM report reaffirmed the community's interest in NASA completing projects initiated in the previous decades: the Stratospheric Observatory For Infrared Astronomy (SOFIA), the Space Interferometry Mission (SIM), and the fifth Hubble Servicing Mission (HST–SM4). SOFIA will be conducting early science flight in 2010 and is expected to reach full operational readiness in 2014. Extensive study and technology development efforts for SIM were conducted throughout the decade. As a result of these efforts NASA better understood the SIM mission and its costs and determined that there were not sufficient funds to fully develop the mission within the decade. In May 2009 HST–SM4 was successfully completed with all mission objectives being achieved. In addition, all early instrument tests are going well and HST is expected to be returning science again later this summer.

Planetary Science:

In contrast to the Astrophysics decadal survey, the 2003–2013 decadal survey for planetary science, entitled *"New Frontiers in Solar System Exploration"* (NFSSE, published in 2003) started its list of mission priorities with smaller missions and moved to medium and large. In today's terms, it proceeds from Discovery missions to New Frontiers missions to Outer Planets Flagship missions. In addition, it prioritized Mars missions separately from other Planetary Science missions.

As recommended in NFSSE, NASA has continued the existing series of Discovery missions. Dawn is on its way to the asteroids Vesta (arriving in 2011) and Ceres (arriving in 2015). The MErcury Surface, Space ENvironment, GEochemistry, and Ranging mission (MESSENGER) mission completed its very successful second flyby of Mercury in October 2008, with its third flyby scheduled for September 2009, and its insertion into Mercury's orbit on schedule for March 2011. The Gravity Recovery and Interior Laboratory (GRAIL) mission is on track for launch in 2011. In addition, NASA is preparing a Discovery Announcement of Opportunity for release later this year to begin planning the next Discovery missions. Also in the "small" investment category, the NFSSE recommended an extended mission for Cassini. The Cassini Extended Mission is underway and is providing excellent data about Saturn and its moons, rings, and magnetosphere. The Mars Science Laboratory, recently renamed Curiosity after a national naming contest, is now scheduled for launch in late 2011.

NASA also fulfilled the recommendation in NFSSE to establish the New Frontiers Program within NASA's Planetary Science budget. The New Horizons and Juno missions were selected via the first two New Horizons Announcements of Opportunity. The New Horizons mission, which is addressing the science objectives of the NFSSE's Kuiper Belt-Pluto Explorer, will rendezvous with Pluto in 2015: NASA's Juno mission, a Jupiter polar orbiter (without probes), is progressing toward its planned launch, also in 2011.

Proposals for other missions in this class included in NFSSE for launch between 2003–2013 (including South Pole-Aitken Basin Sample Return, Venus In Situ Explorer, Comet Surface Sample Return) as well as several 'candidate missions for flight after 2013' (Geophysical Network Science, Asteroid Rover/Sample Return, to Observer, Trojan/Centaur Reconnaissance Flyby) are currently being solicited under the New Frontiers 3 Announcement of Opportunity (AO), with proposals due on July 31, 2009. These and other candidates mentioned in NFSSE were re-affirmed by the NRC prior to the release of the NF–3 AO.

NASA announced in January 2009 that the Europa mission will be the next Outer Planet Flagship (OPF) mission (the survey's highest priority large mission), to be

followed by a Titan mission which was highlighted in the NFSSE report as a candidate mission for beyond 2013. NASA is working closely with the European Space Agency (ESA) on plans for a joint OPF mission that may also include an ESA-provided Ganymede observer similar to what was also included in the 'candidates for flight after 2013' list in NFSSE.

For Mars missions, the NFSSE recommended missions in small, medium, and large categories. In the small category, the report recommended continuation of the Mars Scout line of competed, Principal Investigator-led missions, and a Mars Upper Atmosphere Orbiter. The Mars Scout mission Phoenix successfully landed in the northern polar region of Mars and completed its mission in 2008. The next Mars Scout mission is the Mars Atmosphere and Volatile Evolution (MAVEN) mission, which also fulfills the upper atmosphere orbiter recommendation.

NFSSE recommended the Mars Science Laboratory mission, and this mission is in development for a 2011 launch. The NFSSE identified MSL as a medium-class mission, as it did not include the cost of radioactive power supplies, a launch vehicle, or complete operations costs; nor had the instrument complement been selected. The other NFSSE medium class Mars mission concept was a long-lived lander network; this concept has been studied, but has not been initiated as a mission in this decade.

Finally, NFSSE recommended beginning planning on a Mars Sample Return (MSR) mission for implementation in the decade 2013–2023. MSR concepts have been studied, but mission formulation and implementation have not yet begun. The cost of an MSR mission is such that major international collaborations and contributions will be required. But MSR remains the goal of NASA's Mars Exploration Program.

Life and Physical Sciences Space Research:

Pursuant to direction in the Explanatory Statement accompanying the FY 2008 *Omnibus Appropriations Act* (P.L. 110–161), NASA has asked the NRC to conduct a decadal survey to establish priorities and provide recommendations for life and physical sciences research in microgravity and partial gravity for the 2010–2020 decade. The decadal survey report will provide updated strategic planning advice from representatives of the U.S. research and Technology community to help NASA to define appropriate investments in life and physical sciences research. This study will be the first of its kind regarding this research arena.

Recommendations on the timeline and sequence of research from the NRC decadal study will allow NASA to develop an implementation plan that will impact future exploration missions. The specific objectives of this NRC decadal survey are the following:

- Define research categories that are required to enable exploration missions or those that are enabled or facilitated because of exploration missions;
- Define and prioritize an integrated life and physical sciences research portfolio;
- Develop a timeline from 2010–2020 and define inter-dependencies for objectives;
- Identify terrestrial, airborne, and space-based platforms and facilities that could most cost-effectively achieve the objectives;
- Explain how achieving the objectives will enable exploration, produce knowledge, or provide benefits to space and other applications;
- Identify potential research synergies between NASA and other U.S. Government agencies, as well as with commercial entities and international partners; and,
- Summarize future research objectives beyond 2020.

Although this is the first NRC decadal study in this research area, past NASA studies have been instrumental in helping to set NASA's research priorities. A recent example is related to establishing research priorities for NASA's space biomedical research program that includes ISS research activities as a central component to reducing the risks to crews for future exploration missions. The National Academies through the Institute of Medicine completed its review (July 2008) of the potential hazards and health issues related to long-duration space flight. These risks frame the research to be undertaken by NASA to mitigate the health dangers to crew members. ISS biomedical research is critical to mitigating 17 of the 28 human health risks relevant to exploration. This review builds on the previous National Academies work done for the Bioastronautics Roadmap—a framework developed and used by NASA to assist in identifying research priorities and technology

development, establishing exposure standards, and guiding resource allocation. The resulting IOM report, *A Risk Reduction Strategy for Human Exploration of Space: A Review of NASA's Bioastronautics Roadmap* (IDM, 2006), focused its findings and recommendations on accelerating countermeasure and technology development; establishing a safe radiation exposure level for all relevant risks; and improving the process by which the content of the Roadmap was represented, communicated, and kept current.

Q4b. To what extent does the FY 2010 budget request include funding to begin work on priorities to be recommended in the next three decadal surveys?

A4b. In the FY 2010 President's budget request the NASA sustains support for mission candidates being considered by the decadal survey, such as SIM Lite, IXO, LISA and JDEM, until the decadal survey report is issued in summer 2010. Out-year projections in the FY 2010 request position the division to begin supporting results of the decadal survey through funding available in Future Missions lines. The distribution of funds among the Cosmic Origins program, Physics of the Cosmos program, ExopIanet Exploration program, and basic research and technology will be adjusted to reflect decadal survey priorities and the estimated costs of high priority missions in the FY 2012 and subsequent budget requests. The Agency has requested that the decadal survey recommend how future investments might be balanced among new small, medium, and large mission initiatives, extending on-orbit operations of existing missions, mission enabling technology investments, and research grants.

NASA has funding in the competed mission lines (i.e., Discovery, Mars Scout, and New Frontiers) to support Planetary Science missions identified in the next decadal survey. The final amount of funds available, however, will depend on the timing and content of the next Planetary Science decadal survey. The next Planetary Science decadal survey will not be released until 2011 and will cover the period from 2013 to 2023. However, only 2013 and 2014 are within the five-year budget horizon in the President's FY 2010 budget request.

The President's FY 2010 budget request provides out-year funding to support new missions recommended in the next decadal survey, however, the ability of the FY 2010 budget request to meet the mission recommendations of a future decadal survey will depend on several factors. First and foremost, a lot depends on what the National Academy of Sciences recommends in the form, size (small, medium or large) and complexity of the missions. In addition, NASA and ESA are discussing how to more closely collaborate on both Mars missions and the Jupiter Outer Planet Flagship. The outcome of those NASA–ESA discussions could affect the amount of NASA funds available to support missions recommended in the future decadal survey. The more the Europeans are willing to contribute to the joint Mars and OPF missions, the more NASA funding is freed up to support missions recommended in the next decadal survey.

NASA has worked with the National Academy of Sciences (NAS) to improve the cost realism of missions recommended in the various decadal surveys. Cost estimates from NASA center-proposed missions will be concurred in by NASA Headquarters before they are submitted to the NAS. Further, we are requiring the NAS to contract for independent cost analysis to ensure that each decadal survey-considered mission has some fidelity to its budget estimate.

Finally, since the first-ever decadal survey for life and physical sciences space research is currently under development by the NRC, it is not possible to identify recommended priorities that are contained in the FY 2010 budget. The results of this decadal survey will assist in defining and aligning NASA's space life and physical sciences research based on external experts from the U.S. research and technology community. Further, the recommendations regarding the timeline and sequence of research will allow NASA to develop a research plan and define appropriate investments in life and physical sciences research consistent with national space policy and goals.

Q5. Shuttle transition and retirement costs are quantified in this budget request on the order of about $400 million with possible unfunded threats of $200 million to $300 million. This is a far cry from the $2–$3 billion level mentioned a few years ago. What enabled NASA to make such a big reduction in its estimate? Are there any assumptions, if not realized, that could increase your $400 million estimate?

A5. The NASA estimates of the cost of Shuttle transition and retirement (T&R) have decreased consistently over the past few years. This is due in part because the Agency's Constellation Program requirements are becoming more and more refined, and NASA has gained an improved understanding of which assets may be transfer-

able to that program. NASA treated the first estimates as approximations and chose not to implement these estimates in formal budgets. This allowed the team to understand the cost drivers and systematically remove, refine, and reduce the cost drivers. The Government Services Administration has been helpful in supporting NASA with disposition requirements interpretation and changing processes to allow for more the effective disposition of retired assets. These practical approaches have reduced the estimates for transition. In addition, NASA has explored options for disposing of unassigned assets more cost effectively (e.g., using the DOD approach of dismantling, rather than destroying, certain pieces of equipment).

The Agency's estimates for T&R costs could change depending on the results of the ongoing Review of U.S. Human Space Flight Plans and the Administration's subsequent decisions.

Q6. If the Augustine committee does not recommend continuing to operate the ISS beyond 2015, what, if any, alternative facilities does NASA have for conducting the type of microgravity research needed to enable human space flight beyond low-Earth orbit?

A6. NASA recognizes the value of undertaking research in gravitational and space biology, and as such, NASA utilizes both ground-based and space-based experiments to try to document the health risks to future explorers. Recently, NASA was directed by Congress to have the National Research Council conduct a Decadal Survey to help the Agency establish priorities and provide recommendations for life and physical sciences research in microgravity and partial gravity for the 2010–2020 decade. NASA expects the report to be completed by fall 2010. This report, along with the findings of the Augustine Commission, will influence future Agency plans for microgravity research.

If the ISS is retired, the Agency would plan to continue depending on a variety of platforms that offer varying amounts of time to simulate microgravity: 1) Sounding Rockets; 2) Drop Towers; 3) Parabolic flights; and, 4) Domestic and International free-flyers. In addition, some of the human research and countermeasures validation would be conducted in analog environments such as long-duration bed rest studies. As noted earlier, NASA currently uses these research platforms to develop and validate countermeasures for a large number of human health risks and to conduct high priority research in other life and physical science disciplines to gain an insight of the underlying phenomenon associated with gravity dependent processes.

Q7. In FY 2010, the Aeronautics Research Mission Directorate plans to realign its NextGen work to distinguish research conducted on concepts and technologies from that focused on systems analysis, integration, and evaluation. Will these changes result in accelerating transition of NASA's research to FAA operational use?

A7. The intent of the changes to the projects within the Airspace Systems Program is to provide a structure that will allow more efficient and effective management of efforts to conceive and develop advanced NextGen technologies while reducing risk and accelerating timely transition those technologies to implementing organizations. The new structure will support and enhance existing efforts to initiate integrated system research in key areas of R&D gaps identified by JPDO and will include the collaborative engagement with the FAA as planned within the recently created Research Transition Teams to accelerate progress for NextGen advancements.

The work will transition, from the laboratory to the field, key concepts within the baseline Airspace Systems Program integrating surface, terminal, transitional airspace and en route capabilities to enable operational enhancements envisioned by NextGen. Since the technical maturity of research concepts will largely take place within the Concept and Technology Development project, resources must be well invested there to generate the research products to transition at later points as part of integrated systems. In fact, some capabilities are expected to be transferred at low maturity levels directly from the Concept and Technology Development project, because the FAA has expressed a need for some advanced algorithms for early incorporation in current air traffic control tools.

The development of infrastructure for systems analysis, integration, and evaluation will be managed within the Systems Analysis, Integration, and Evaluation project. It will assess and validate collective impact of technologies using fast-time modeling, simulation, and field evaluations and will feed back results into the baseline program to enhance and validate research concepts. This validation and integration of research products in relevant environments will be a multi-year process, and will accelerate and reduce the risk of transition of research products to the implementing agency.

Q8. The Committee expressed concern that adequate maintenance and upgrading of facilities be performed on a regular basis in the 2008 NASA Authorization Act. *In that legislation, the NASA Administrator was directed to determine and prioritize the maintenance and upgrade backlog at each of NASA's Centers and associated facilities and* "develop a strategy and budget plan to reduce that maintenance and upgrade backlog by 50 percent over the next five years." *In view of the projected funding for facilities and maintenance projected through FY 2014, how long will it likely take to eliminate this backlog?*

A8. NASA will present the requested data as part of the FY 2011 budget request.

Questions submitted by Representative Gabrielle Giffords

Q1. Another impact of the tight budgets you have been given in recent years is that a number of your programs appear to have very thin reserves. For example, the FY 2010 budget request for the Space Shuttle program has minimal reserves at the same time that NASA is acknowledging that the Shuttle program has cost and schedule threats that it must guard against. Thus the budget request assumes that the flight schedule can be maintained but with almost no leeway to deal with uncertainties. What options does NASA have if unforeseen events do materialize?

A1. Operational programs typically have much lower levels of funding reserves than do development programs simply because of the steady-state nature of the work being done. In addition, the potential technical challenges to operational programs tend to be better understood than those of programs still in development. The Space Shuttle Program has sufficient resources to fly out the remaining manifest, including the flight of the Alpha Magnetic Spectrometer (AMS), before the end of FY 2010. NASA intends to fly out the Shuttle manifest safely as possible until its retirement. However, as there is no budget for flying into FY 2011, the Agency would have to determine the optimal approach for providing resources to support missions delayed beyond this point.

Q2. An important part of NASA's portfolio is its science program. What are the most significant challenges in space science and Earth science over the period covered by the President's FY 2010 five year budget runout? To what extent can those challenges be addressed with the resources requested in the FY 2010 budget? Where are the shortfalls that will need attention in future budget requests?

A2. NASA faces the challenge of implementing the 27 innovative science missions, including NOAA reimbursable GOES missions the Agency has in formulation or development, but these are fully funded in the FY 2010 budget request and run out.

NASA's science priorities are guided by NRC decadal surveys, one of which (Earth Science) was received for the first time in 2007 and three of which will be updated and delivered over the next three years (Astrophysics, Planetary Science, and Heliophysics). These surveys convey science community priorities, and their results influence budget submissions. The FY 2010 budget request, along with resources provided in the *American Recovery and Reinvestment Act* allows for steady progress in achieving the priorities recommended in the current decadal surveys in Earth science, planetary science, astrophysics, and heliophysics. While NASA expects the forthcoming surveys to continue to guide these programs, managing scientists' expectations that NASA will be able to fund all of their priorities consistent with the budget horizon will be a challenge.

Q3. The FY 2010 budget request for Earth Science does not include resources to fly a replacement of the Orbiting Carbon Observatory, which was lost due to a launch failure in February 2009, or a similar sensor. What impact would a decision to develop a replacement for OCO have on the overall Earth Science program if additional funds for an OCO replacement were not provided?

A3. Following the loss of OCO in February 2009, the mission's science team concluded that an OCO reflight or a functionally equivalent mission was necessary to advance carbon cycle science and to provide the basis for thoughtful policy decisions and societal benefits. In response, NASA evaluated a range of options to develop and launch a replacement instrument or acquire data from international missions. Of the options under consideration, the most mature and best-understood option is to rebuild an OCO mission with as few changes as possible and launching the so-called "Carbon Copy" into its planned orbit as an element of the "A-Train." Such a mission could have a minimum development time of 28 months and cost approximately $331M.

NASA is working to implement the balanced program recommended by the National Research Council's Decadal Survey in Earth Science, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*. In preparing its recommendations, the NRC assumed the successful launch of OCO and therefore did not recommend any near-term carbon monitoring missions which would be included in NASA's budget. If a decision was made to re-fly OCO and if the required funding for an OCO replacement would come from within the Earth Science portfolio, it would delay the development and launch readiness dates of existing or new missions.

Q4. The FY 2010 budget request for NASA's Education programs represents a reduction of $43M from the FY 2009 enacted budget. What is the reason for the reduction and what was cut?

A4. The President's budget request of $126.1M for NASA Education reflects the funding required to execute the Agency's education plan in FY 2010. The FY 2010 budget request for NASA Education is an increase of $10.5M from the FY 2009 budget request.

The FY 2010 budget request does not contain the Congressional plus-ups of FY 2009 for the National Space Grant College and Fellowship Program (Space Grant) and the Experimental Program to Stimulate Competitive Research (EPSCoR), nor does the FY 2010 budget request include funding for other Congressionally-directed activities added in FY 2009.

The FY 2009 budget request was $115.6M, with $169.2M enacted.

The enacted FY 2009 budget included the following Congressional modifications from the original budget request:

+53.6M, Funds four Congressionally-directed projects (*Competitive Educational Grants Program; Global Climate Change Education; Science Museums and Planetariums Grants; and NASA visitor centers*) and increases two existing projects (*Space Grant and EPSCoR*).

- **+$16M,** Fund a Competitive Educational Grant project as directed
- **+$10M,** Fund a Global Climate Change Education project as directed
- **+$7M,** Fund a Science Museums and Planetarium Grants project as directed
- **+$7M,** Fund Education projects at the 10 NASA visitor centers as directed
- **+$11.7M,** Increase EPSCoR to $20.0M as directed
- **+$11.3M,** Increase Space Grant to $40M as directed
- **-$8.9M,** Elementary, Secondary and e-Education core programming
- **-$1.0M,** Informal Education core programming
- **+$0.1M,** Minority University Research and Education Program
- **+$0.5M,** Higher Education programming

Q5. What specific insight do you have in the progress of the two COTS vendors? Is simply meeting the scheduled contract milestones to justify vendor payment enough to give you confidence that each vendor can perform agreed to flight demonstrations?

A5. NASA is pleased with the progress that our funded COTS partners have made to date in meeting the terms of their Space Act Agreements (SAAB). Both commercial partners continue to make steady progress in achieving their cargo demonstration milestones. While each has experienced some milestone delays, this is not unexpected, since both partners have aggressive, success-oriented schedules, and are facing challenges typical of a space flight development program. As such, NASA sees no reason to doubt either company's ability to achieve its desired objectives—that of demonstrating commercial cargo delivery to and from the International Space Station (ISS).

As of July 2, 2009, SpaceX had completed the first 14 of 22 milestones and has received a total of $234M in payments with $44M available for the retraining milestones. SpaceX has completed the majority of Dragon capsule qualification testing. Technical progress is being made and qualification testing is progressing on the Falcon 9 launch vehicle as well. SpaceX has begun manufacturing the flight Dragon capsule and Falcon 9 to be used for the COTS demonstration flight 1.

Recently, SpaceX notified NASA that the company expects delays in completing its three demonstration flights. According to the terms of the current SAA, SpaceX was supposed to complete its first demonstration flight in June 2009 so as to allow

additional time for Falcon 9 manufacturing and testing programs. SpaceX now expects to complete its first demonstration flight in January 2010, with the second and third flights now planned for June 2010 and August 2010, respectively.

The Orbital demonstration flight is currently planned for March 2011 due to the company's decision to change its cargo transportation architecture from an unpressurized (external) cargo system to a pressurized (internal) cargo system. However, delays such as these are not unexpected since both partners have aggressive, success-oriented schedules, and are facing challenges typical of a space flight development programs. It is important to note that NASA will not pay for any milestone missed until the milestone is successfully completed per the SAA and approved by NASA. Should a milestone be missed, NASA will evaluate partner progress made and recommend future actions that are in the best interest of the government.

Although meeting existing SAA milestones is a primary indicator of progress, and completion does increase our confidence levels, it is not the only indicator. The Commercial Crew & Cargo Program Office (C3P0) maintains technical, programmatic, and schedule insight into the COTS partners' progress. The program office includes representation from the Safety Technical and the Engineering Technical Authorities who provide independent progress insight for each partner. The ISS program office maintains independent insight into partner progress as well, in order to verify ISS visiting vehicle interface and safety requirement compliance.

The C3PO has established the COTS Advisory Team (CAT) comprised of approximately 100 NASA technical experts from across the Agency. These experts review partner technical and programmatic progress for each milestone and provide progress assessments to the C3PO. Additionally, they participate in all major design reviews providing technical review comments back to our partners. The CAT provides another method by which NASA gains confidence that our partners will be able performs their flight demonstrations.

As mentioned above, each COTS partner must successfully verify they comply with a detailed set of ISS interface and safety requirements prior to their planned ISS berthing missions. These requirements are imposed on all Visiting Vehicles wishing to dock to the ISS. Both COTS partners are currently working with the ISS program on a daily basis to ensure they meet the ISS Visiting Vehicle requirements, providing independent insight into their progress and building confidence.

Please see milestone charts on attached pages.

Q6. After the successful Hubble servicing mission, it seems that the ability to perform human repair is something worth keeping. What plans are there, if any, for including provisions in the design for putting some sort of robotic arm on Orion or its service module?

A6. The Orion Crew Exploration Vehicle was designed from the beginning to be a versatile spacecraft, with the possibility that additional capabilities not included in the current baseline design could be added at a later date, depending on mission need and funding availability. Currently, NASA does not have a requirement for a robotic arm for Orion's missions to the International Space Station and the Moon. However, should a requirement arise, and additional funding becomes available, the Orion could be adapted via future upgrades or "kits" to include a robotic arm, for example. The baseline Orion architecture has already allocated mass and volume for "unpressurized cargo," which will accommodate such kits and thereby precluding the need for a redesign of the Orion vehicle architecture should such upgrades be required at a later date.

Q7. Now that the Exploration strategy is essentially put on hold for three months, how is NASA proceeding with attempting to secure international participation in future exploration activities? How is NASA's experience with the ISS informing discussions with potential exploration partners?

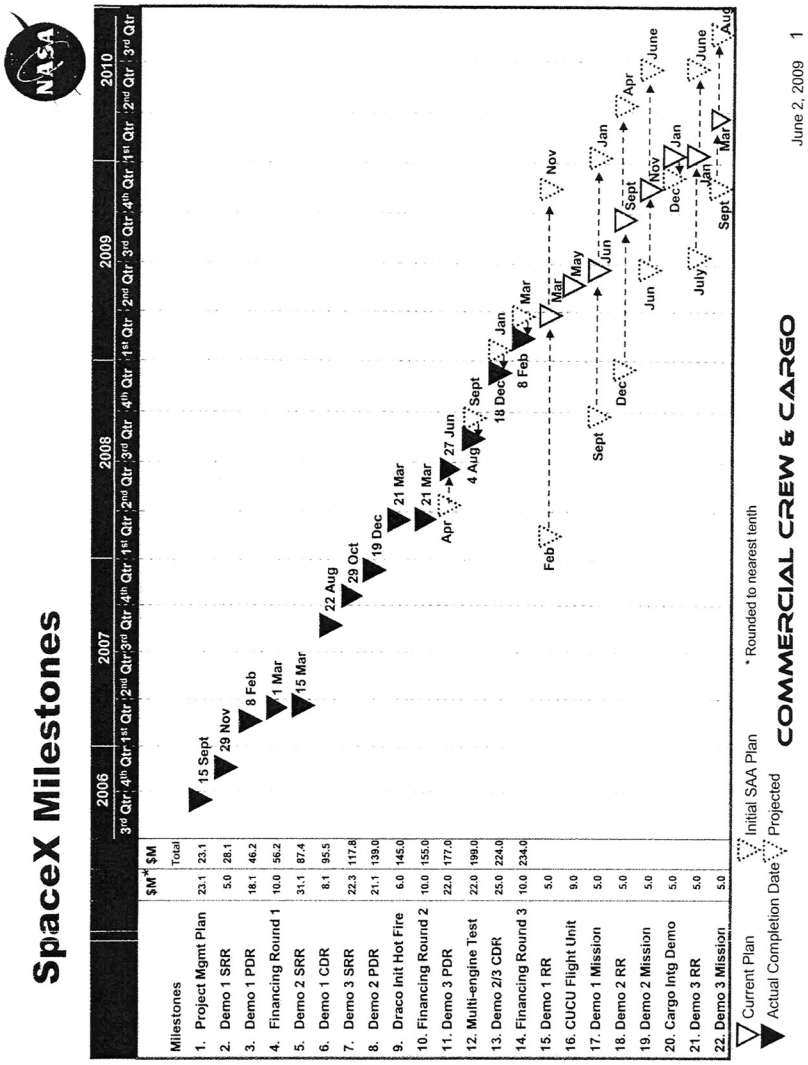
A7. During the Review of the Human Spaceflight Plans, NASA did not initiate any new human lunar exploration activities. That said, NASA has continued to pursue its four pronged international engagement strategy related to establishing interest in lunar exploration cooperation. Specifically, NASA continued to: (1) meet NASA's commitments to its International Space Station (ISS) Partners; (2) conduct multilateral dialogue with space organizations which have expressed interest in the Moon; (3) conduct bilateral technical discussions and identify areas of potential cooperation; and, (4) seek other complementary initiatives that support NASA's plans to explore beyond Low Earth Orbit with humans and robots.

NASA's early decision to meet its ISS commitments after the Space Shuttle's return to flight and NASA's leading role in the development of common principles for exploration among 14 space agencies under the banner of the "Global Exploration Strategy (GES)" have convinced potential international partners that NASA is seri-

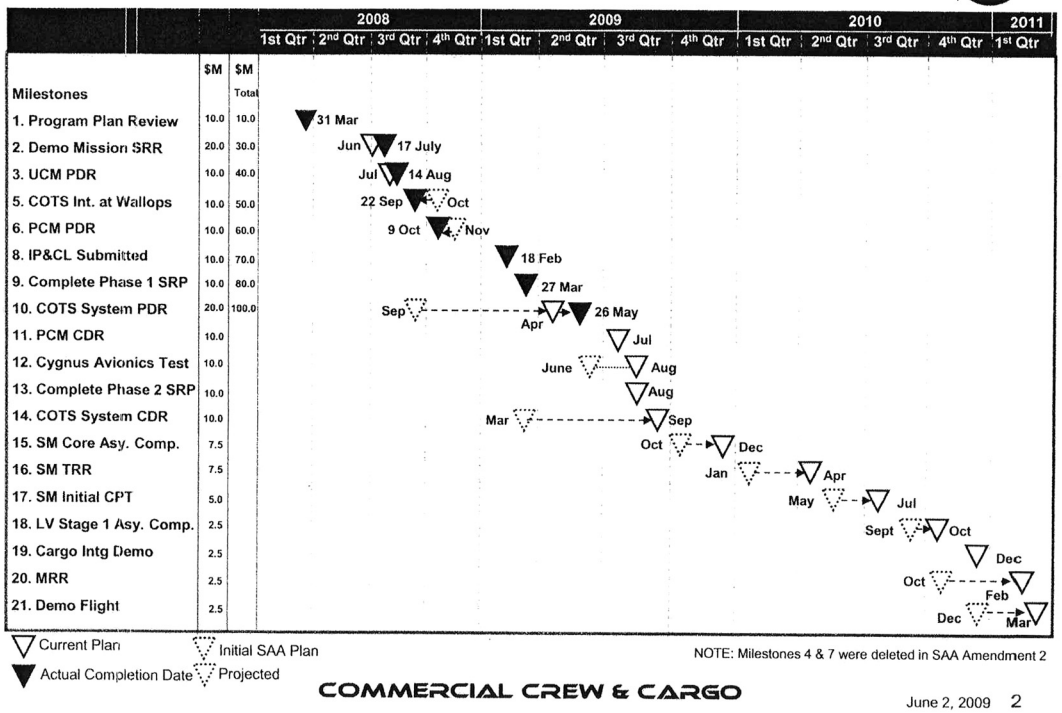
ous about international cooperation in exploration. Multilaterally, NASA led the development and release in May 2007 of the Global Exploration Strategy Framework Document as well as its follow-on, 13-agency coordination mechanism called the International Space Exploration Coordination Group (ISECG). Under NASA's leadership, the ISECG is continuing work to define candidate human and robotic lunar architectures.

Bilaterally, NASA has had initial significant successes in completing lunar robotic cooperative agreements with India (Chandryaan), Japan (Selene/Kaguya), and Russia (LRO). Other discussions and precursor activities are underway with space agencies in such countries as Canada, ESA, Germany, India, Italy, Japan, Korea, Russia, and the United Kingdom. Finally, NASA is seeking other complementary initiatives such leading the development of a multilateral set of lessons learned from ISS to help exploration, advocating more research using the ISS as a testbed that feeds forward to human lunar exploration, and stimulating international scientific interest in the Moon through the NASA-led International Lunar Network (ILN) concept.

NASA's success in its international discussions continues to help lay the foundation for future sustained and affordable space exploration activities by the United States.



Orbital Milestones



NOTE: Milestones 4 & 7 were deleted in SAA Amendment 2

Question submitted by Representative Ben R. Luján

NASA's participation in NM spaceport:

Q1. Last year NASA examined whether the NM space flight program could carry NASA instruments and investigators into space cost effectively. The Ames Research Center briefed NM on the potential of NASA's use of the NM spaceport for sub-orbital research. Does NASA intend to pursue this potential, or continue studying the use of sub-orbital passenger carrying capabilities in the NM spaceport?

A1. NASA is studying the use of commercially available, passenger carrying sub-orbital rockets as a science platform, and has created a Human Sub-orbital Flight Program led by the Space Operations Mission Directorate (SOMD). The SOMD will work with service providers as capabilities become available to acquire services to support NASA users selected through a competitive process.

The NASA Science Mission Directorate (SMD) is always interested in any platform that enables *science.* The SMD has issued multiple calls for Earth and space science investigation ideas. SMD issued two Requests for Information (RFIs) (Feb/Mar 2008; Sep/Dec 2008) seeking expressions of interest in potential NASA science investigations and payloads/experiments taking advantage of the new platforms. The response was low for both RFIs, totaling only six responses suggesting a concept for an Earth or space science investigation (14 responses suggested Exploration Systems Mission Directorate-relevant investigations).

A NASA Research Announcement was issued (Aug/Dec 2008) seeking proposals for *funded* concept studies in Earth and space science using any capability of the new platforms. Again, the number of responses was low—17 compliant proposals. These were subjected to standard community peer review. Most proposals fared poorly in peer review, rated as poor science or poor use of the platform. The only highly rated proposal was selected for a one-year funded concept study—"Firefly on Demand," PI: Joanne Hill, USRA/GSFC, for study of terrestrial gamma-ray flashes emitted during thunderstorms and their impact on upper atmosphere energetics.

While these efforts have not identified uses for such platforms for the space and Earth sciences, NASA is continuing to explore this concept and the potential benefits it might bring to other areas of research and technology development. Since the vehicles to provide these services are still in various stages of development and testing, it will take time for this activity to mature.

Questions submitted by Representative Charles A. Wilson

Q1. How is NASA working with DOD, DOE, FAA, and other agencies to enable aircraft to operate with non-petroleum based fuels?

A1. NASA is working with a number of agencies to investigate non-petroleum fuels for aircraft use. The Agency is performing research to develop combustors with reduced emissions capable of operating on a wide range of fuels. While recent flight demonstrations have shown that current aircraft engines can operate with alternative fuels, NASA intends to develop methods to maximize the efficiency of combustors regardless of the type of fuel. In addition, NASA will ensure that the differences between the fuels are well understood and that there are no long-term detrimental issues with utilizing alternative fuels. In this activity, NASA is actively engaged in a number of research activities. Some of the main ones include developing and evaluating advanced combustion concepts using conventional and alternative fuels, improving computational combustion codes to improve emissions predictive capability to enable better combustion systems to be designed, and emissions testing of aircraft engines. Other aspects of this research includes characterizing new fuels to insure they meet the minimum requirements (e.g., freeze point, flash point, etc.) and that lab burner and engine tests prove feasibility of safely operating on alternative fuels.

The Air Force has a very large program to certify and investigate the use of non-petroleum fuels for their fleet. NASA has benefited from collaborating with the Air Force on this alternative fuel research. The Agency has purchased two Fischer-Tropsch (F–T) fuels in conjunction with the Air Force and is currently involved in a new purchase to obtain a substantial quantity of biojet fuel for our research activities. NASA has also collaborated with the Air Force in exchanging fuel property data for a number of alternative fuels. The Air Force has provided data to NASA on their engine emissions measurements using alternative fuels. NASA and the Air Force recently collaborated on emissions testing using a Pratt and Whitney 308 engine with F–T fuel and the Aviation Alternative Fuel Emissions Experiment

(AAFEX) using a NASA DC–8 aircraft with two F–T fuels. The Air Force was an active participant in both of these tests and sent a research team and instrumentation to participate in the tests. NASA has also teamed with the Air Force Research Laboratory for combustion flame tube testing using a CFM–56 sector with a Fischer-Tropsch fuel. Some of NASA sponsored work on alternative fuel chemical kinetics was recently provided to the Air Force for their use.

NASA also works with the FAA for non-petroleum fuels. NASA participates as a member of the FAA Commercial Aviation Alternative Fuel Initiative (CAAFI) and attends CAAFI meetings, serves on a number of CAAFI teams, and participates in road mapping exercises. Through the CAAFI coalition NASA also learns what research others are performing, learns what fuel and emissions characteristics data are needed for alternative fuel certification and then develops roadmaps for NASA alternative fuels research aimed at obtaining and disseminating the required information.

NASA has also worked with The EPA on sampling emissions from aircraft in the Aircraft Particle Emissions Experiment and AAFEX measurement campaigns to evaluate emissions from numerous aircraft engines. EPA sent a research team and participated in these experiments at various locations across the country. NASA is also working with DOE in the biofuels area. The Agency currently has a space act agreement in process for DOE to characterize oil samples obtained from various biofeedstock sources.

Q2. How can NASA's capabilities in aerospace power technologies and systems be applied to help solve our nation's energy challenges?

A2. As a research and development agency, NASA has a unique role in government to support civil aeronautics research. Therefore, the Agency can have the most significant impact by focusing on improving the efficiency (and coincidently minimizing the environmental impact) of the air transportation system. The NASA Aeronautics program conducts cutting-edge, long-term research in areas that are well aligned with the National Aeronautics R&D Policy guidance and with the high-priority national aeronautics R&D goals and time-phased objectives established by the National Plan for Aeronautics R&D and Related Infrastructure.

Much of NASA's civil research can also directly benefit military aircraft. Through close partnership with the DOD, NASA also helps to improve the efficiency of military aircraft. The impact of this research is most profound for the U.S. Air Force because fuel costs have a major impact on the service.

While it is important for NASA to focus on air transportation challenges, other sectors can benefit from NASA's technologies. Since the restructuring, there has been a renewed emphasis on the publication of research results, preferably in peer reviewed venues. A primary reason for this emphasis is to help ensure technical excellence of NASA's work, but another significant benefit is the dissemination of knowledge to the broader community. Such dissemination facilitates the transfer of knowledge in areas such as computational fluid dynamics, materials and structures, and aerothermodynamics that may help meet the broader energy challenges that face the Nation.

From a space perspective, as part of the NASA Exploration Technology Development Program (ETDP), NASA is developing advanced lithium-ion batteries and hydrogen-oxygen fuel cells to store energy at the lunar outpost, and to power lunar rovers and space suits. These energy storage technologies could help to increase the driving range of terrestrial electric vehicles, and to increase the battery life of portable consumer electronic devices such as cell phones and laptop computers. Work on these technologies is taking place at the NASA Glenn Research Center (GRC) in Ohio and the NASA Jet Propulsion Laboratory in California. As part of the ETDP, GRC also is developing Stirling power convertors for small nuclear reactors and radioisotope power systems to generate power for the lunar outpost. Stirling convertors could be used for Earth-based power generation systems that use concentrated solar energy or waste heat from power plants.

The NASA Johnson Space Center in Texas, in coordination with other NASA centers, has the lead for developing lunar electric rovers that will be used by the Constellation Program during human lunar missions. The largest of the rovers, named the Lunar Electric Rover, is designed to carry two astronauts hundreds of miles across the lunar surface. These rovers share many common technology development requirements with electric vehicles on Earth (energy storage like batteries, electric motors, recharging systems, new tires, etc.). Because of this need, NASA is pursuing partnerships both with other government agencies and U.S. industry partners to ensure NASA is at the forefront of electric vehicle technology development. The technologies developed for the Lunar Electric Rover may be helpful in enabling technologies for electric cars and electric heavy equipment used on Earth.

NASA's Innovative Partnerships Program has also supported renewable energy research and partnerships, with 76 projects recently, including 45 from Small Business Innovation Research (SBIR), 18 partnership projects, seven jointly-funded Seed Fund technology development projects, five Small Business Technology Transfer (STTR) projects and one Centennial Challenges competition. The projects involved many technologies including solar power, fuel cell technology, laser power, and nano-material and cryogenic applications.

The attached summary was developed in March 2009, in response to a request from the House Subcommittee on Space and Aeronautics for information to support the Subcommittee's planned round table regarding renewable energy.

Q3. Given the history of NASA in spinning out commercializations, does the committee feel NASA is receiving adequate funding for support of patent protection, licensing, and commercialization activities with companies to develop new technologies?

A3. The NASA Innovative Partnerships Program (IPP) conducts technology development to meet the Agency's needs and technology transfer for a broad spectrum of technologies having applicability across key U.S. industrial sectors. In addition, IPP provides and facilitates a grassroots opportunity for U.S. businesses, academia and citizens to apply their innovations to NASA missions. Funding for IPP activities pays dividends toward U.S. industrial competitiveness in global markets, and in sparking young people's interest in STEM disciplines.

The current budget plans for FY 2010 and out years in the IPP budget will lead to a reduction in current service levels, especially in Partnership Development. Partnership Development includes licensing out of NASA technology and facilitating the protection of the government's rights in its inventions, as mandated by a long history of legislation, as well as partnering with external entities for joint development of critical, near-term, cutting edge technologies having both NASA mission use and commercial applicability.

Q4. What are NASA's plans to invest in technologies to improve the efficiency of turbine engines to reduce carbon emissions?

A4. The most direct way to reduce carbon emissions in the near-term is to improve the efficiency of jet aircraft engines since approximately 20 pounds of carbon dioxide are emitted for each gallon of aviation fuel burned. The key to quiet, efficient aircraft propulsion is to move large amounts of air at velocities that are not much higher than the aircraft's forward flight speed. To date NASA has been moving in this direction with ever-larger turbofan engines. However, we are approaching the point where nacelle size, weight, and drag are offsetting the noise and efficiency gains. We are currently performing research aimed at lowering the weight and drag of nacelles for ultra-high bypass turbofans and increasing the fuel-burn efficiency of the core engine which powers the large fan. One of the next steps in improving engine efficiency is open-rotor technology which removes the nacelle and uses large-diameter prop-fan rotors, but that too has its limitations. Currently, open-rotors are noisier than large turbofans and we are performing research aimed at significantly reducing the noise in order to capitalize on the fuel-burn benefits which open-rotors offer compared to large turbofans. Technology improvements to ultra-high bypass turbofans and open-rotor engines are expected to enable new engines in the 2020 time frame which burn 25 percent less fuel than today's engines. Aircraft engine manufacturers as well as Airbus and Boeing are considering open-rotor propulsion systems for the next generation of single-aisle commercial transport aircraft, expected to enter service around 2020. Part of their decision on whether to adopt open-rotor technology rests on the success of our current efforts at reducing the noise of open-rotors. More advanced propulsion technologies are expected to involve hybrid propulsion systems in which gas turbine engines drive electric generators which in turn power electrically-driven fans, with many fans distributed along the airframe. Other changes might involve embedding engines in the airframe to eliminate the large nacelles which cause drag, or coupling gas turbine engines with fuel cells to generate electric power for fans. In general we envision propulsion architectures which no longer feature just two or four large engines suspended below the aircraft wing. Embedded-engine and distributed propulsion technologies are not currently expected to be ready for entry into service until 2030 or beyond.

In addition, NASA will continue to invest in advanced combustor technologies that are more efficient than today's systems. An important aspect of this work is to enable the development of combustors that can operate at peak efficiencies with a variety of fuel types, including alternative fuels such as biofuel. NASA has unique expertise with the understanding and predicting the impact of these fuels on com-

bustor systems, and these contributions will help ensure that aircraft engines can operate effectively if these new fuels become viable.

Q5. Current program plans for human space flight assign significant roles and responsibilities and provide for commensurate funding and workforce participation for a number of NASA Centers including the Glenn Research Center. What will NASA do to insure that any changes in plans resulting from the independent review of human space flight activities will be implemented in a manner which continues to effectively utilize the capabilities of the various Centers supporting NASA's Exploration Mission?

A5. When Center exploration-related work assignments were determined in 2007, NASA followed a formal process in which current and future potential center skills were assessed. The proposed lunar work assignments were then coordinated with NASA senior management and formally presented at the Senior Management Council for final Agency approval. If changes are made following the Administration's response to the independent Review of U.S. Human Space Flight Plans, NASA will ensure that each Center contributes appropriately to the revised plan.

Q6. NASA is to be commended for its acknowledgement that industry, academia, and non-profit organizations will be the implementers of technology into products. The maturing and integrating of Aeronautics technologies for accelerated transition to practical application is important for both environmental and economic competitiveness reasons. The Budget Request describes an acquisition strategy for the Integrated Systems Research Program which allocates only $10 million of the $62.4 million of FY 2010 funding for grants, contracts, and cooperative agreements with industry, academia, and non-profit organizations. Please describe why such a small percentage of the budget is designated for this effort, as well as the smaller sum, contained within that figure, for grants, contracts, and cooperative agreements. What are the plans to increase this amount in the future?

A6. The FY 2010 budget request for NASA Aeronautics Research of $507M is adequate to support a healthy program that addresses aviation's effect on the environment. This funding level allows the Agency to continue the fundamental research approach that conducts cutting-edge, long-term research in areas that are well aligned with the National Aeronautics R&D Policy guidance and with the high-priority national aeronautics R&D goals anal time-phased objectives established by the National Plan for Aeronautics R&D and Related Infrastructure. In addition, with the approximately $60M increase in funding request above the FY 2009 President's budget request run-out, we will add a significant systems-level research component centered on environmentally friendly technologies. The Integrated Systems Research Program (ISRP) will conduct research at an integrated system-level on promising concepts and technologies and explore, assess and demonstrate the benefits in a relevant environment. The goal of the first project in ISRP, the Environmentally Responsible Aviation (ERA) project, is to explore and document the feasibility, benefits, and technical risks of vehicle concepts and enabling technologies identified to have the potential to mitigate the impact of aviation on the environment.

NASA's overall Aeronautics program achieves its expected role and contributions within the current budget by focusing on NASA's unique capabilities and by maximizing coordination and collaborations with industry, academia, and other government agencies. We are able to fund a workforce at four NASA research centers (Ames, Dryden, Glenn, and Langley) that allows for robust implementation of our research programs in such a manner that our workforce is sustained as a premier technical organization and a true national asset. 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 (SAAB) 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. It is anticipated that these mechanisms, as well as competitive procurements, will be utilized to involve the private sector in ISRP and ERA. NASA plans to allocate ~$15M towards NRA in FY 2010, which equates to roughly 24 percent of the program budget, which is greater than the amount allocated by the other research programs. In addition to the NRA, it is anticipated that a significant amount of the remaining funds within the program will be used for out-of-house procurements on advanced concepts and testing. An acquisition strategy plan will be developed in FY 2009 to identify and outline the strategy for the larger procurements and collaborative efforts of the project.

NASA Innovative Partnerships Program
Renewable Energy Projects

	IPP Source	Project Name	Partner Organization(s)	NASA Center	Duration (months)	Key Contact Person	Project Description
1	Partnership Development	Assessment of Scalable Modular Photobioreactor for Closed System Algae Growth	Bodega Algae	ARC	12	Lee Bebout	Develop of prototype photobioreactor for algal growth for biofuel applications
2	Partnership Development	Demonstration for Algal CO2 Removal	California Air Resources Board	ARC	18	Brad Bebout	Demonstrate the use of algae for biofuel applications to capture carbon from power plant exhaust. Decision on Award by October 2009
3	Partnership Development	Algal-Derived JP-8 Fuel	Carbon Capture Corp.	ARC	36	John Hogan	Development of algal system for producing jet fuel. DARPA Solicitation. Decision on Award by late summer 2009
4	Partnership Development	NanoSIP Developing Community Imaging for Phylogenetic and Functional Characterization	DOE	ARC	36	Lee Bebout	Working with LLNL, conducting research on imaging technologies to understand complex algal mat communities for biofuel applications
5	Partnership Development	A Google-Ames Exploration into Global Research into Energy and the Environment at NASA	Google	ARC	12	Jonathan Trent	Google Energy FY08. Research on the use of enzyme systems to breakdowon cellulose for biofuel applications
6	Partnership Development	Green Initiatives	Google	ARC	12	Jonathan Trent	Google Energy FY09: Research on enzyme systems for cellulosic biofuels, devleopment of marine algae growth technology, and remote sensing to a common architecture such as Google Earth
7	Partnership Development	Biorefinery Development for Algal Biofuel	PrimaFuel	ARC	9 years	John Hogan	Development of algal system for producing algal biofuel. DOE solicitation
8	Partnership Development	Solar Thermal Technology Prototype for Earth and Space Applications	SolFocus	ARC	18	Christopher McKay	Demonstration of prototype solar thermal system
9	Partnership Development	Development of Increased Efficiency Solar Cells Using Sculpted Substrates	St. Lawrence Energy	ARC	12+	Meyya Meyyappan	New nanotechnology design for solar cells. Original RSAA was for 12 months. Anticipate renewal to extend effort for additional 12 months.
10	Partnership Development	Development of Nanoparticle solar concentrator and materials for heat removal	Sunrgi	ARC	36	Chris McKay	Development of novel NASA solar concentrator technology with expertise to remove produce new materials to remove concentrated heat
11	Partnership Development	Development of Nanostructured Ezyme Complexes for Cellulosic Feedstocks	USDA-DOE	ARC	12	Chad Paavola	Development of enzyme systems for cellulosic ehtanol biofuel applications
12	Partnership Development	Sensor Development for Improved Algal Growth and Production	USDA-DOE	ARC	24	Brad Bebout	Development and demonstration of sensor system to improve the growth of algae for biofuel applications
13	Partnership Development	Feasibility of Using Algae as a Source for Food and Biofuels	Wellspring	ARC	60	Brad Bebout	Characterize algae for specific food and biofuel applications. Develop photobioreactor and open pond sensing technology. Award expected FY10
14	SBIR	Stress-induced bandgap-shifted titania photocatalyst for hydrogen generation	Nanoptek	ARC	25	John Guerra	Phase II will continue developing the efficient production of hydrogen from water using sunlight and nanostructured titania thin-film semiconductor electrodes achieved in Phase I, delivering a solar hydrogen generator. Titania?s (TiO2) absorption cutoff is moved from UV (414 nm) to visible (529 nm) by shifting the energy bandgap to ~2.0 eV, through stress induced by the nanostructured template. The disorder/strain distribution forms amorphous/strained titania with a high density of states localized within the energy band gap. Absorption of 29% of the solar spectrum is achieved, more than 5X improvement over single-crystal TiO2. The nanostructures enhance total absorption through multiple total internal reflections, eliminating the need to track the sun. A prototype three-electrode electrochemical cell evolves hydrogen at 2 mL/(s?W?m2) ? a solar-efficiency of 8% after light source correction; electrochemistry data shows 20% efficiency is attainable. Efficient conversion of water to hydrogen fuel with sunlight is ideal for closed environments like the International Space Station, with continuous recycling of hydrogen from contaminated water back to clean water when combined with
15	Partnership Development	High Efficiency Solar Power	Dryden Flight Research Center, ERAST Alliance, SunPower Corporation	DFRC	7 years	Greg Poteat	A state-of-the-art solar farm featuring the latest in high-efficiency solar cells available for terrestrial is in use at NASA's Dryden Flight Research Center. Manufactured by SunPower Corporation of Sunnyvale, Calif., the A-300 silicon cells were derived from those developed for the NASA/AeroVironment Helios and Pathfinder-Plus solar-powered aircraft under the now-concluded Environmental Research Aircraft and Sensor Technology (ERAST) program. They are considered to be the most advanced photo-voltaic cells available for terrestrial applications and are providing the NASA Dryden Strategic Communications building with a significant portion of its electrical power needs. The A-300 is an efficient, high-performance, low-cost, single crystal silicon solar cell, with a unique, all back-contact design. It offers up to 50 percent more power than conventional solar cells. Homes across the country are now being outfitted with this modern, space-age solar power. The Dryden solar farm was configured in 2003 with the first commercially available SunPower arrays, and the site has recently been upgraded with new arrays allowing for the prototypes to be evaluated by the company's R&D department for continu
16	Seed Fund	Human-Rated Space Power Systems Pallet demonstrating fuel cells, lithium-ion batteries and advanced thermal management technologies	Boeing, Teledyne, Fred Beast/Center for Space Power; GRC	GRC	26	Kathy Needham; Michelle Manzo; Mark Hoberecht	Develop and demonstrate an advanced power system pallet design - integrating fuel cell, advanced thermal and water management technology, battery with advanced management system. TRL advancement of component technologies.

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	IPP Source	Project Name	Partner Organization(s)	NASA Center	Duration (months)	Key Contact Person	Project Description
17	SBIR	Co-Generation of High Purity Hydrogen and Electric Power	Ceramatec, Inc.	GRC	24	Patricia Vaughn	The proposed innovation is an integrated hybrid solid state electrochemical system providing co-generation of high purity hydrogen and electric power. The embodiment is a physical, chemical and thermal integration of three processes: (1) production high purity hydrogen, (2) electrochemical partial oxidation of hydrocarbon fuel, and (3) power generation by a solid oxide fuel cell. This highly integrated, multi-function system eliminates any need for the CO shift and cleanup process steps currently required to generate hydrogen for use in Proton Exchange Membrane fuel cell power plants being considered for aircraft electric propulsion and power needs. It also eliminates the efficiency penalty imposed by use of conventional partial oxidation reformers. Thermal integration of the endothermic hydrogen generation processes with the exothermic SOFC operation achieves several benefits, notably higher efficiency by chemical recuperation and much lower air pre-heater duty (size, weight and cost) by eliminating the need for excess cooling air. The process facilitates sequestration of fuel carbon content by segregation of product CO2 from non-condensable gases. This innovation closes a significant void in the technology required to in
18	STTR	Multijunction Ultralight Solar Cells and Arrays	EIC Laboratories, Inc.	GRC	24	Krishna C. Mandal	There is a continuing need within NASA for solar cells and arrays with very high specific power densities (1000-5000 kW/kg) for generating power in a new generation of ultralight space payloads. An emerging technology with promise to meet these ambitious goals are solar cells based on very thin films of discrete layers or interpenetrating networks (IPNs) of organic donors and acceptors. It is also recognized in the field of thin film inorganic solar cells, that it is possible to stack cells tuned to the blue, green and red portions of the solar spectrum, thus harvesting photons with less degradation of their energy. Theoretical efficiencies for multijunction solar cells are ~70% compared to ~30% for single junction devices. Indeed, these multijunction solar cells hold the current record for solar conversion efficiency. In this proposed joint STTR program between EIC Laboratories and the University of Florida, we will develop multijunction organic donor-acceptor solar cells as a means to achieve higher efficiencies than can be realized with single junction devices. Phase II will continue with development of high mobility, bandgap engineered organic donors and acceptors, as well as develop three junction devices and scaled up de
19	Partnership Development	Quantum Dot Photovoltaic Test Laboratory	Essential Research	GRC	12	Michael Piszczor	Essential Research installed a clean room, test procedures, and software in its new quantum dot photovoltaic test laboratory with NASA assistance. The new facility has attracted additional business for the company, and is able to support NASA Glenn work in space optical communications.
20	SBIR	High Efficiency Quantum Dot III-V Multijunction Solar Cell for Space Power	Essential Research, Inc.	GRC	24	Samar Sinharoy	We are proposing to utilize quantum dots to develop a super high-efficiency multijunction III-V solar cell for space. In metamorphic triple junction space solar cells, pioneered by Essential Research, Inc., the InGaAs junction or bottom cell of the three-cell stack is the current limiting entity. In Phase I of this program, we demonstrated that InAs quantum dots can be formed by MOVPE, and then incorporated in an InGaAs cell to provide sub-gap absorption and thus improve its short-circuit current. For the Phase II work, we propose to optimize this quantum dot InGaAs cell, and develop a three-cell stack to achieve a space solar cell whose efficiency would dramatically exceed current SOA standards. A theoretical estimate predicts that a InGaAlP(1.95 eV)/InGaAsP(1.35 eV)/InGaAs(1.2 eV) triple junction cell incorporating quantum dots to improve the bottom cell current would have an efficiency exceeding 40%. Quantum dots will allow NASA not only to improve device efficiency by expanding the spectral response of individual cells, but to improve the temperature coefficients and radiation tolerance as well. This is extremely important as NASA attempts to increase array specific power with new concentra
21	SBIR	Radiation Resistant, Improved Emissivity Solar Cell System using PBO Film	Foster-Miller, Inc.	GRC	24	Dr. Nese Orbey	Current and future thrusts within NASA call for the availability of high efficiency, high reliability, space-hardened energy supply systems. NASA will benefit from availability of these systems in its push towards expanding mankind?s understanding and place in space. One technology having the most potential for serving NASA objectives is thin-film photovoltaics. Great advances have been made over the past 20 years in photovoltaic technology, and thin-film devices are no exception. However, these advances have not led to the realization of the combination of high efficiency and high power density required for future NASA applications. One shortcoming has been the substrate material. In this Phase II program, Foster-Miller proposes the continued development of a substrate that will enable the realization of NASA?s long-term goals. Among commercially available polymeric materials, PBO is the only material exhibiting the high temperature stability and high mechanical strength necessary to achieve the high efficiency and high power density required for these missions to come to fruition. This Phase II effort will address the space-stability problem - common among polymeric substrates - for PBO by identifyi
22	SBIR	Advanced Composite Bipolar Plate for Unitized Regenerative Fuel Cell/Electrolyzer Systems	Giner Electrochemical Systems, LLC	GRC	24	Cortney Mittelsteadt	Development of an advanced composite bipolar plate is proposed for a unitized regenerative fuel cell and electrolyzer system that operates on pure feed streams (H2/O2 and water, respectively). The composite bipolar plate can greatly simplify "closed-loop" unitized fuel cell/electrolyzer power systems, as it eliminates the need for saturators, a second stack and water/gas phase separation. It provides a substantial system improvement over presently used alkaline systems in that it allows for simple high pressure operation with a high differential pressure. Additionally, it allows for dead-ended H2 and O2 feed for the fuel cell, eliminating parasitic pumping losses required for water removal. Phase I demonstrated operation of a composite bipolar plate-based fuel cell and electrolyzers, and quantified the composite bipolar plate transport and mechanical properties required for system design. In Phase II a full size unitized composite bipolar plate designed will be designed for high pressure (>1000 psi) operation. In addition a full-size (2kW) stack and support system will be designed.
23	Partnership Development	Photovoltaic Powered Soap Dispensors	GOJO	GRC	12	Michael Piszczor	Solar cell technology is being applied as a "no touch" power source for automated soap dispensors.
24	SBIR	Advanced Product Water Removal and Management (APWR) Fuel Cell System	Infinity Fuel Cell and Hydrogen, LLC	GRC	24	William F Smith	The proposed innovation is a passive, self-regulating, gravity-independent Advanced Product Water Removal (APWR) system for Polymer Electrolyte Membrane (PEM) primary fuel cell power plants that improves power plant efficiency and reliability, reduces reactant consumption, cost, weight and volume and simplifies the supporting system requirements in both near-term and advanced missions. Phase I program single cell test results demonstrated the function and feasibility of the innovation. The APWR power plant study demonstrated reliability, reactant saving, weight and volume saving and scalability improvements relative to both alkaline and conventional PEM power plants. Elimination of the pumps, rotating water separators and other components these conventional systems require saves weight, eliminates parasite power, saves the reactants to produce parasite power and improves reliability. APWR also simplifies the stack saving weight and volume and providing power plant scalability. APWR is based on PEM technology proven in automotive and commercial applications but not applied to space power plants. NASA need not carry the cost burden of developing this technology alone. The proposed Ph
25	SBIR	CuInGaAlSe2 Solar Absorbers On Flexible High-Temperature Substrates	ITN Energy Systems, Inc.	GRC	26	Lawrence Woods	ITN Energy Systems (ITN) proposes to take the next step in spacecraft solar array development, building upon previous development and new findings to make the definitive light-absorber layer for high-power, lightweight and flexible thin-film photovoltaics (TFPV). ITN's innovative approach is to alloy CuInSe2 (CIS) with both aluminum and gallium bandgap widening elements in the chalcopyrite matrix to form CuInGaAlSe2 (CIGAS) for simultaneous optimization o the bandgap and material properties. Both Ga and Al will be used to take advantage of the alloy enhancing properties that each offers when used in moderation, while avoiding the detrimental issues when using too much of any one element to achieve the optimum bandgap of about 1.45 eV for a single-junction in the space solar spectrum. Furthermore, a recently available novel lightweight, flexible and transparent substrate will be used that was specifically designed to enable high-temperature CIGAS depositions as needed for the highest efficiency TFPV. TFPV specific power of over 1500 W/kg at the

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	IPP Source	Project Name	Partner Organization(s)	NASA Center	Duration (months)	Key Contact Person	Project Description
26	SBIR	Lightweight InP Solar Cells for Space Applications	MicroLink Devices	GRC	24	Noren Pan	The innovation in this Phase II SBIR is the development of a technology which will enable the manufacture of a lightweight, low cost, high radiation resistance InP based solar cells with high efficiency suitable for space power systems. The key technological step is the application of a production-worthy epitaxial liftoff (ELO) process to a multijunction solar cell structure fabricated on a large area (3-inch and 4-inch)InP substrates. Our focus will be on the improvement of the efficiency of dual junction to greater than 23% and a pathway towards InP based triple junction. The number of substrate reusage will also be investigated to determine the impact of cost savings due to the high cost of InP substrates. Radiation testing of the ELO InP solar cells will be performed and compared to standard InP solar cells.
27	Seed Fund	Alternative Fuels for Next Generation Combustor Applications	Pratt & Whitney	GRC	17	Kathy Needham, Dr. Lee, Dr. William Sowa	To determine the the advantages and drawbacks of exercising Fischer-Tropsch fuel, biomass fuelsand Technology Element 22 fuel for the advancement of subsonic aircraft and to provide a fundamental basis for assessment of chemical/physical properties and combustion characteristics and for deciding what fuels are optimal from technical and practical constraints.
28	SBIR	Novel Materials that Enhance Efficiency and Radiation Resistance of Solar Cells	Sun Innovations, Inc.	GRC	24	Ted Sun	Spacecrafts rely on arrays of solar cells to generate electrical power. It is an on-going challenge to maximize electrical power available to spacecraft while reducing overall stowage volume and mass of solar array, which requires developing more efficient solar cells with higher specific power density. The objective of this SBIR project is to develop a generic approach, based on novel functional nano-materials, to significantly increasing the solar cell efficiency (~10%), specific power density, radiation resistance and lifetime, without adding much cost or weight to the existing solar cells. The feasibility to synthesis such nano-materials has been explored and demonstrated in Phase I. Without optimizing, preliminary test on commercial solar cells show an efficiency gain approaching 5% after applying such nano-materials. Such nano-materials will be further improved for energy efficiency and environmental durability in Phase II, to reach the objective of at least 10% gain in energy efficiency on majority of commercial solar cells
29	Seed Fund	New Lithium-Ion Battaeries with Enhanced Safety and Power Density for Future NASA and Aerospace Missions	T/J Technologies, Inc. , ABSL Space Products, Northrop Grumman	GRC	24	Gary Horsham Partnership Manager, Richard Baldwin; Ratnakumar Bugga	Performance validation of an alternative, high rate and inherently safe lithium-ion cell chemistry and to assess the viability for near term human and robotic exploration missions and for commercial aerospace mission applications.
30	Partnership Development	recovery of exhaust heat, NEOGEN Energy Harvester,	Thermo-Mechanical Systems Branch , Glenn Research Center	GRC	12	Duane Beach	Every day, energy is blown into the atmosphere through power plant smokestacks and industrial and commercial heating systems. In an effort to recover and transform low-temperature waste heat into usable electronic power, Unitel Technologies received a NASA grant to build a prototype waste heat-recovery system called NEOGEN. The goal was to achieve a nominal energy-savings gain of approximately 20 percent over the recuperated binary Rankine cycle. The work was carried out with assistance from the Glenn researchers and engineers from Creare, Inc., who aided in the development of the thermodynamic-analysis software. Moreover, an award from the NASA Illinois Commercialization Center supported NASA's thermodynamic-efficiency analyses of NEOGEN. Unitel Technologies plans to use the system to recover energy from other industrial plants, as well as commercial plants, electric utility facilities, diesel engines, and gas turbines. (http://www.sti.nasa.gov/tto/Spinoff2005/er_7.html)
31	SBIR	Integrated Three-Port Converters for Compact and Efficient Power Management	APECOR	GRC	24	Antoine Khoury	To meet the increasing power demand of today's spacecraft systems, an integrated power electronics system capable of interfacing, and simultaneously controlling, three power ports is proposed in this project. This new proposed power electronic architecture employs a single-stage power topology, thus allowing cost-effective control of power flow with improved efficiency, power density, and reliability. The project is developing an innovative, dc-dc converter which can effectively manage the interface of a source, a load, and an energy storage function within a single-stage, three-port topology. Modern advances in digital control, in conjunction with a novel power processing concept make this logical next-step possible. This unique topology and controller function together to realize three power processing paths which simultaneously utilize the power devices, allowing increased functionality while promising reduced losses and enhanced power densities. Control objectives include battery charge regulation, solar array peak power tracking, and/or load voltage regulation. The Phase I efforts completed the preliminary analysis and the proof-of- concept prototyping. A demonstration test was successfully conducted substantiati
32	SBIR	CuInGaAlSe2 Solar Absorbers On Flexible High-Temperature Substrates	Ascent Solar Technologies, Inc.	GRC	26	Janet Casteel	ITN Energy Systems (ITN) proposes to take the next step in spacecraft solar array development, building upon previous development and new findings to make the definitive light-absorber layer for high-power, lightweight and flexible thin-film photovoltaics (TFPV). ITN's innovative approach is to alloy CuInSe2 (CIS) with both aluminum and gallium bandgap widening elements in the chalcopyrite matrix to form CuInGaAlSe2 (CIGAS) for simultaneous optimization of the bandgap and material properties. Both Ga and Al will be used to take advantage of the alloy enhancing properties that each offers when used in moderation, while avoiding the detrimental issues when using too much of any one element to achieve the optimum bandgap of about 1.45 eV for a single-junction in the space solar spectrum. Furthermore, a recently available novel lightweight, flexible and transparent substrate will be used that was specifically designed to enable high-temperature CIGAS depositions as needed for the highest efficiency TFPV. TFPV specific power of over 1500 W/kg at the blanket/module level would be achievable The novel transparent substrates would also enable additional power from bifacial visible light collection and lowe
33	SBIR	Novel Solar Cell Nanotechnology for Improved Efficiency and Radiation Hardness	CFD Research Corporation	GRC	24	Ashok Singhal	Significant improvements in photovoltaic materials and systems are required to enable NASA future exploration missions. In this project, CFD Research Corporation (CFDRC) with University of California Riverside (UCR), Rochester Institute of Technology, and International Photonics will: 1) develop and provide reliable, validated computational tools for assessment, design, and optimization of novel nanostructures based on Quantum Dots (QD) for future nano-devices for space applications; 2) investigate, design, and demonstrate new photovoltaic (PV) structures based on QD nanotechnology, with improved efficiency and radiation hardness. The inherently radiation tolerant quantum dots of variable sizes maximize absorption of different light wavelengths ("multicolor" cell), which dramatically improves photovoltaic efficiency and diminishes the radiation-induced degradation. Phase 1 included development of numerical tools for modeling electron-phonon transport in quantum-dot for photovoltaic applications, using experimental data from UCR Nano-Device Laboratory for validation and calibration of the models, computational and experimental proof-of-concept. In Phase 2, the new QD models wil
34	SBIR	High-Efficiency, High-Temperature, Ultra-Lightweight GaP-Based Solar Cells	EpiWorks, Inc.	GRC	24	David Ahmari	The objective of this proposal is to study and demonstrate novel GaAsNP/GaP/AlGaP technology for use in extreme photovoltaic (PV) energy conversion. NASA and the scientific community are interested in solar missions that go as far as Saturn or even into near sun conditions. Such missions present a challenging problem for PV technology. In addition to the requisite high efficiency and reduced solar cell payload mass, these missions require a PV technology that can withstand the increased solar intensity, radiation and temperature. We propose studying two possible solar cell designs. The first design utilizes novel, wide gap GaP-based materials to provide bandgaps well suited for high-temperature operation and to enhance function in high radiation and near sun missions. Such an approach will enable solar cells to operate at and above 450 Celcius with the highest possible efficiency. As part of this study we would investigate the deposition of AlGaP on GaP to provide materials with bandgaps at or above 2.4 eV. The second design we will investigate uses more standard materials that EpiWorks has already developed for different applications. This design would employ InAlP (2.4eV bandgap)

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	IPP Source	Project Name	Partner Organization(s)	NASA Center	Duration (months)	Key Contact Person	Project Description
35	SBIR	High Efficiency Quantum Dot III-V Thermophotovoltaic Cell for Space Power	Essential Research Inc	GRC	24	William King	For NASA deep space science missions, radioisotope thermoelectric generators (RTG) fueled by plutonium-238 are used to provide on-board source of heat, which is then converted to electricity. At present, NASA uses 8% efficient thermoelectric conversion systems. Compound semiconductor thermophotovoltaic (TPV) cells provide an attractive alternative. The highest efficiency TPV cell reported is a 23.6% (radiator at 1039?C, cell at 25?C) InGaAs monolithically interconnected module (MIM) on InP. We proposed an InGaAs TPV cell which incorporates InAs quantum dots to provide sub-gap absorption thus improving its short-circuit current. This cell could then be integrated into a MIM to achieve a TPV cell whose efficiency would significantly exceed (by about 15% to 20%) the state-of-the-art. In Phase I we demonstrated the feasibility of growing InAs quantum dots on 0.6 eV InGaAs on lattice-mismatched InP, and that these quantum dots, when inserted into the TPV cell, extend the bandedge, providing sub-bandgap absorption. In Phase II we propose to optimize the quantum dot structures to improve efficiency of the TPV cells, and integrate them into MIMs to achieve very high conversion efficien
36	SBIR	Electrolyzer for NASA Lunar Regenerative Fuel Cells	Giner Electrochemical Systems, LLC	GRC	24	Anthony Vaccaro	Water electrolyzer stacks are a key component of regenerative fuel cells, designed to replace batteries as a means of storing electric energy on the lunar surface. The delivery of a 2,000 psi balanced pressure, lightweight prototype electrolyzer is proposed. The cell design will be significantly smaller and lighter, and capable of higher pressure operation than previous aerospace electrolyzers designed and built by Giner Electrochemical Systems, LLC. The successful completion of Phase I yielded test data, trade studies, a thin frame design, and model enhancements that would provide the basis of stack sizing. In a Phase II program, an enhanced, 2,000 psi test stand will be created by upgrading the existing 1,200 psi stand. It will then be used to demonstrate thin frame designs, the robustness of internal components, and the innovative prototypical compression hardware at realistic conditions. Further advances in thin frame technology will be investigated, and additional analyses of a new thermoplastic material will be conducted with the prospect of using them in the deliverable if these technologies are ready.
37	SBIR	Nanostructured InGaP Solar Cells	Kopin Corporation	GRC	24	Roger Welser	Current matching constraints can severely limit the design and overall performance of conventional serially-connected multijunction solar cells. The goal of this SBIR program is to enhance the operating tolerance of high efficiency III-V solar cells by employing nanostructured materials in advanced device designs. A larger fraction of the solar spectrum can potentially be harnessed while maximizing the solar cell operating voltage by embedding thin layers of narrow band gap material in a higher band gap matrix. Nanostructured devices thus provide a means to decouple the usual dependence of short circuit current on open circuit voltage that limits conventional solar cell design. While previous experimental work on quantum well or quantum dot solar cell devices has typically employed GaAs as the wide band gap matrix, we take a different approach, instead employing InGaP as the barrier material. During the Phase I effort, we observed that thin InGaP layers can be extremely effective at reducing the dark current. A novel device structure resulted in over a 100 mV enhancement in the open circuit voltage of GaAs PIN diodes solar cells without any degradation in the short circuit current. The Phase II program
38	SBIR	Ultra-Lightweight High Efficiency Nanostructured Materials and Coatings for Deep Space Mission Environments	Nanosonic, Inc.	GRC	24	Lisa Lawson	NanoSonic has developed a nanostructured spray self-assembly manufacturing method that has resulted in ultra-lightweight (< 0.4g/cc) textile interconnects for photovoltaic arrays, durable EMI shielding (-70 dB) solar collector membranes with unprecedented flexibility (> 1000%), and multi-layer, high efficiency thermal rejection coatings for deep space missions. NanoSonic has analyzed opportunities for its unique self-assembly processing techniques with the Photovoltaic and Space Environments Branch at NASA GRC. Focus was placed on radiant heat barrier coatings formed as multiple organic and inorganic well-defined segments using spray-based self-assembly processing. The spray technique allows the incorporation of materials required to achieve high coating reflectivity with low absorptivity and high emissivity over large-area NASA structures. The low /coatings will be transitioned to use on NASA deep space mission structures, near space airships and commercial rooftops and buildings. NanoSonic has also developed ultra low mass density fabric materials with patterned conductive traces capable of conducting high electrical
39	SBIR	High Operating Temperature, Radiation-Hard MIM Thermophotovoltaic Converters	Spire Corporation	GRC	24	Mark Little	Spire Corporation is developing a key component for thermophotovoltaic (TPV) power technology for deep space missions. We are developing InGaAs monolithically interconnected modules (MIMs) that convert thermal photons from the 1100C General Purpose Heat Source (GPHS) into electrical power. The innovation is that these MIMs are designed to operate at higher cell temperatures (150C) and be more radiation-hard than current MIMs to better match the cell environment on missions. In Phase 1, we developed a model that predicts an optimum InGaAs bandgap (adjustable during epigrowth) for the operating temperature and 1100C blackbody GPHS spectrum of 0.7eV, made sample devices, and tested temperature coefficients to confirm the model and measured data agree (e.g. model predicts ?1.7mV/C for Voc vs. ?1.8mV/C for data). In Phase 2, we will perform five iterations of a model, design, epitaxially grow, process, and test cycle. Data from each cycle will be used to improve the next design. Testing will include both radiation, temperature stability and accelerated life testing. Before program completion, we will survey NASA and commercial space power contractors for needs and make sampl
40	STTR	600 Volt Stretched Lens Array for Solar Electric Propulsion	ENTECH, Inc.	GRC	24	MarkJ.O'Neill	ENTECH, Auburn, NASA, and others have recently developed a new space photovoltaic array called the Stretched Lens Array (SLA), offering unprecedented performance (>80 kW/cu.m. stowed power, >300 W/sq.m. areal power, and >300 W/kg specific power) and cost-effectiveness (>75% savings in $/W compared to planar arrays). SLA achieves these outstanding attributes by employing flexible Fresnel lenses for optical concentration (e.g., 8X), thereby minimizing solar cell area, mass, and cost. SLA's small cell size (85% less cell area than planar high-efficiency arrays) also allows super-insulation and super-shielding of the solar cells to enable high-voltage operation and radiation hardness in the space environment. Recent studies show that SLA offers a 3-4X advantage over competing arrays in specific power for many NASA Exploration missions, and that SLA is ideally matched to Solar Electric Propulsion (SEP) applications, which can save NASA >$10 billion for lunar exploration cargo transportation. In Phase II, ENTECH and Auburn wil perform critical ground tests, including an advanced solar concentrator (1 kW, 600 V, color-mixing lenses, multi-junction cells) direct-driving a Hall-effect ele
41	STTR	InN-Based Quantum Dot Solar Cells	Kopin Corporation	GRC	24	RogerEWelser	The goal of this STTR program is to employ nanostructured materials in an advanced device design to enhance the tolerance of solar cells to extreme environments while maintaining high solar electric power conversion efficiency. By using InN-based quantum dots embedded within a higher band gap GaN barrier material, a larger fraction of the solar spectrum can be harnessed while minimizing the effects of high temperatures and high-energy radiation with this promising photovoltaic device. The wide range of energies accessible to InN-based materials provides unique flexibility in designing quantum dot solar cell structures. Phase I work demonstrated the feasibility of synthesizing device quality InN-based quantum dots. InN quantum dot assemblies were grown on GaN templates via metalorganic chemical vapor deposition and exhibited well defined x-ray diffraction peaks with dot densities up to 1E10 cm-2. More importantly, strong room temperature photoluminescence has been observed, with peak emission energies ranging from the infrared to the ultraviolet. These promising optical properties suggest it will be possible to build structures incorporating InN quantum dots within a GaN p-n junction to test the basic c
42	Centennial Challenges	Green Aviation Challenge	Comparative Aircraft Flight Efficiency Foundation, HQ	HQ	34	Andrew Petro	Prize competition for demonstration of highly-efficient aircraft using electricy, renewable fuels or a combination to achieve greater than 100 mpg-equivant at more than 100 mph with 200 mile range. Details of competition are in-work with partner under existing Space Act Agreement and funds for prize are already obligated.

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43	SBIR	Advanced Approaches to Greatly Reduce Hydrogen Gas Crossover Losses in PEM Electrolyzers Operating at High Pressures and Low Current Densities	ElectroChem, Inc.	JPL	24	Radha Jalan	ElectroChem proposes a Phase II program to advance its very successful SBIR Phase I technology effort to the point of minimum hydrogen loss through the electrolyzer membrane, while the high proton conductivity necessary for high efficiency water electrolysis is maintained. In Phase I, ElectroChem demonstrated that its concept of adding clay to a Nafion proton conductive membrane would significantly reduce the penetration of hydrogen gas through the membrane. In Phase II, a comprehensive technology effort (aimed at optimization) will be carried out which uncovers the microscopic changes that occur within the membrane as a result of the clay addition. The objective of this effort is first to correlate the microscopic morphology that occur within the Nafion-clay nanocomposite membranes with the reduction in hydrogen penetration produced by the clay addition. A second objective is to control the microscopic morphology and establish a process to develop the most effective Nafion-clay nanocomposite membranes, leading to advanced MEAs. The final objective is to evaluate the Nafion-clay nanocomposite membranes under high pressure Commercial Electrolyzer conditions. Successful completion o
44	SBIR	Dimensionally Stable Membrane for High Pressure Electrolyzers	Giner Electrochemical Systems, LLC	JPL	24	Anthony Vaccaro	Utilizing high strength polymers with controlled pore dimensions as a support, a customized membrane electrode assembly (MEA) can be generated for NASA's electrolyzer and fuel cell stacks that has optimized electrochemical performance with greatly improved mechanical properties enabling high pressure (>1000 psi) operation. The overall objective is to optimize DSM-based MEAs for a NASA lunar application. This will be accomplished through six tasks. 1. Extending GES's gas crossover and chemical degradation mitigation strategies to DSMs 2. Improving DSM with better ionomer; 3. Optimize the anode, 4. Optimize DSM MEAs for H2/O2 fuel cells. 5. Update GES model for electrolyzer and fuel cell performance. 6. Use model to select optimal DSM for lunar electrolyzer application and generate MEAs for full-size stack.
45	SBIR	In-Situ Production of Hydrogen for Buoyancy on Titan	Lynntech, Inc.	JPL	24	Cindy Barnett	Resupply of materials in space applications is a significant logistical problem. Historically the replacement materials have been carried with the spacecraft. This problem increases dramatically as mission duration and distance from the earth increases, as in missions to Saturn or Titan. It is estimated that a buoyant vehicle operating on Titan may require 75 g of make-up hydrogen per week. This represents approximately 35 kg of additional mass at launch solely for the storage of make-up hydrogen to maintain buoyancy of the craft on Titan for a one-year mission. During the Phase I project Lynntech demonstrated that hydrogen can be generated in-situ directly from the Titan atmosphere from 100 K to 300 K with 10 watts using proprietary plasma reformation techniques, and that metal hydrides are viable hydrogen separation devices. Lynntech's low volume, low mass (2 kg) system will save approximately 33 kg at launch (>$72M) for a one year Titan mission. Based on a conservative estimate (using Mars mission equivalency factors), Lynntech's proposed system has an advantageous equivalent system mass (ESM) after only 47 mission days. The Phase II effort will focus on further impr
46	SBIR	High Temperature Energy Storage for In Situ Planetary Atmospheric Measurement Technologies	Mobile Energy Products, Inc.	JPL	24	Dave Lucero	Development of energy storage capable of operational temperatures of 380?C and 488^oC with a specific capacity 200 Whr/kg for use as a power source on the Venusian surface and for planetary probes in similar high temperature atmospheres and where ambient pressures of 90 atmospheres are to be expected. This proposal provides for further research and development of the Li/Al/CoS2 high temperature energy storage chemistry to develop high temperature space energy storage, which will enable the in situ exploration of the atmosphere of Venus and deep atmospheres of Jupiter or Saturn for
47	Seed Fund	Flight Demonstration Of A Lander Using Lox/Methane	Armadillo Aerospace	JSC	15	Michelle Brekke; Eric Hurlbert; Tim Smith; HUU Tinnh	Atmospheric Flight test data on lander using LOx/Methane propellants, and vacuum performance data of lander engine. LOx provides capability for future In-situ propellant usage, LOx based system are ECLSS and power compatible. Lox/methane technology is applicable to commercial ETO spacecraft Infusion.
48	Seed Fund	Safer Li-Ion Rechargeable Cells for Energy Storage	Engineering	JSC	12	Dr. Judith Jeevarajan	To obtain safer lithium-ion rechargeable cells using a self extinguishing electrolyte
49	Partnership Development	High Solids Anaerobic Digestion- Biogasification Study	JSC Sustainability Partnership Team, University of Florida	JSC	18	Mike Ewert	Analysis and conceptual designs of a high-solids anaerobic digester are being conducted for 2 applications: space mission waste, such as from a lunar habitat and Johnson Space Center organic waste. The energy potential of converting these waste streams to biogas is being assessed by analysis and testing.
50	Seed Fund	Safer Lithium-Ion Rechargeable Cells For Energy Storage	Quallion, LLC	JSC	12	Michelle Brekke; Judith Jeevarajan; Richard Deloof; Michelle Manzo; & Thomas Miller	Demonstrate safe lithium-ion rechargeable cells that do not go into flames under abusive conditions such as overcharge, overdischarge, external and internal short circuits.
51	SBIR	High Capacity Anodes for Advanced Lithium Ion Batteries	TDA Research	JSC	6	Dr. Judith Jeevarajan	SBIR contract to obtain high energy and ultra-high energy safe Li-ion batteries for the Constellation customers - two contracts
52	SBIR	New Li Battery Chemistry for Improved Performance	TH Chem	JSC	6	Dr. Judith Jeevarajan	SBIR contract to obtain high energy and ultra-high energy safe Li-ion batteries for the Constellation customers - two contracts
53	SBIR	Nano-Engineered Materials for Rapid Rechargeable Space Rated Advanced Li-Ion Batteries	Yardney Technical Products, Inc.	JSC	24	Dr. Judith Jeevarajan	SBIR contract to obtain high energy and ultra-high energy safe Li-ion batteries for the Constellation customers - two contracts
54	SBIR	Integrated PEMFC Flow Field Design Concept for Gravity Independent Passive Water Removal	ElectroChem, Inc.	JSC	24	Radha Jalan	ElectroChem proposes a Phase II program to advance its very successful SBIR Phase I PEM fuel cell (PEMFC) program. In Phase I, the unique integrated-flow-field design (IFF) has been shown to provide highly superior passive water management that results in a H2/O2 PEMFC that is gravity independent, achieves higher voltage efficiencies than conventional PEMFC designs, can be operated safely at high pressure (with resulting higher efficiencies), will enable passive operation, and requires extremely low excess O2 to maintain stable operation. The Phase II Program will bring ElectroChem's IFF PEMFC concept to the threshold of commercialization. In Phase II, scale-up and IFF optimization will be carried out. For complete passive operation, stack systems will incorporate an ejector to produce the low reactant flows and for product water removal. High performance membrane electrode assemblies (MEAs) will be developed. These Ph II efforts will produce a 250W IFF stack deliverable that will be integrated directly into NASA's Exploration Energy Storage Plan. The use of the IFF innovation will significantly simplify PEMFC operation and will result in higher and safer performance.

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55	SBIR	Multifunctional Fibers for Energy Storage in Advanced EVA Systems	ITN Energy Systems, Inc.	JSC	24	Ashotosh Misra	The overall objective of the Phase II effort is to demonstrate prototype multifunctional EVA system power patches that integrate energy storage into advanced space suit systems' components (suit and pack) to increase functionality and decrease weight and volume. The program will optimize materials and plasma processes to bridge the performance gap between current fiber and planar batteries. Optimized fiber batteries will be integrated into prototypes relevant to anticipated NASA missions. Successful completion of the Phase II will lead to an engineering demonstration unit that powers a distributed sensor under conditions that are compatible with anticipated missions. Additional integrated power pack designs such as composites based on fiber batteries will be also evaluated. The lessons learned in this effort will establish guidelines for effective development and transition of future generations of MFF into EVA systems and other applications.
56	SBIR	Integrated Microchannel Reformer/Hydrogen Purifier for Fuel Cell Power Systems	Makel Engineering,Inc.	JSC	24	Darby Makel	Makel Engineering, Inc. (MEI) supported by Lockheed Martin and the Colorado School of Mines (CSM) propose to develop an integrated hydrogen generator and purifier system for conversion of in-situ produced hydrocarbons to fuel-cell-grade hydrogen. With increased space exploration activities, mobility on planetary surfaces becomes a vital resource: without mobility on the surface, exploration activities are limited to landing sites. There are many needs and many solutions to the mobility challenge, depending on the distance and nature of the transportation required. Rovers provide a range of transportation possibilities, from the very small rovers for site recognition to the large rovers for crew transportation during extra vehicular activities (EVA). While very small rovers may be powered by photovoltaic cells, fuel-cell based power systems may be the alternative to power mid-size to large rovers. Due to the various penalties of storing gaseous hydrogen on-board the rover, it is advantageous to carry methane instead of hydrogen and to have an on-board reformer to produce hydrogen on-demand for the fuel cell. Proton exchange membranes (PEM) are currently the choice on many fuel-cell based power sys
57	SBIR	Compact Water Electrolyzer for Low-Gravity Environments	MicroCell Technologies	JSC	24	Michael C Kimble	NASA uses a number of water electrolysis units for generating oxygen and hydrogen gas for space applications. These missions range from generating propellants to supplying oxygen to crew and habitat. Consequently, the electrolyzer systems employ a variety of designs and system approaches that can generate high pressures or product gases with varying degrees of moisture, however, most of these approaches result in heavy and bulky systems. A new water electrolyzer was developed by MicroCell Technologies that allows pressurized gas to be generated in a lightweight and compact design. In a Phase I SBIR program, we demonstrated the feasibility of the electrolyzer to generate pressurized oxygen and hydrogen gas in a compact and lightweight electrolyzer design that can operate in a passive mode without requiring water pumps. Based on these results, we propose to scale the process in a Phase II program to a rate of 0.5 kg O2/hr in a device with a mass of 1000 g and a volume of 300 cc. This translates into high power densities of 6 kW/kg and 18 kW/liter, competitive metrics for an electrolyzer that can also generate high pressure to 2000 psi in a passive balance of plant approach.
58	SBIR	Selective Photo-Initiated Electrophoretic Separator	Physical Optics Corporation	JSC	24	Gordon Drew	Physical Optics Corporation (POC) proposes to develop a Selective Photoinitiated Electrophoretic Separator (SPIES) System to address NASA's volatile gas separation and collection needs on the moon and Mars. It will process gas streams generated by upstream lunar in-situ resource utilization (ISRU) processes to produce purified gases such as hydrogen, oxygen, water vapor, and others that support human habitat here. The SPIES system, consisting of a series of compact (<20 cm diameter, 60 cm long, <5 kg) and energy efficient (<30 W) modules, produces highly purified gases of interest at ambient temperatures and pressures, requires no consumables, and eliminates the need for extensive downstream equipment thus, reducing equipment launch size and weight by 33%. In Phase I, POC designed and assembled a proof-of-concept prototype of technology readiness level (TRL) 4 that successfully demonstrated purification of simulated lunar ISRU hydrogen gas streams by gas separation and extraction to reduce hydrogen sulfide contamination to <1 part per million (ppm). In Phase II, POC will optimize the system design to assemble a fully functional TRL 5 SPIES system prototype that will efficiently red
59	SBIR	All-Passive Lightpipe Illumination	Applied Optical Materials	KSC	6	David Schaafsma	An all-passive fiberoptic lighting systems that can be used on long space missions or here on earth. By addressing the traditional problems of concentration and solar tracking in a novel way, we will create a high efficiency lighting system that is also very durable and inexpensive.
60	Seed Fund	Dust Mitigation for Solar Panels	Florida Solar Energy Center	KSC	10	Robert M. Reedy	Inclusion of the dust mitigation technology on solar panels for terrestrial applications. This technology could lead to increased cell performance in dusty or remote environments where physical cleaning of the panels may not be feasible or cost effective.
61	SBIR	Biomass Production System	Orbital Technologies Corp.	KSC	18	Thomas M. Crabb	The BPS provides several growth chamber configurations (baseline of 4) with temperature and humidity environment, nutrient and water delivery, lighting, and atmospheric composition control in the confines of a double middeck locker volume.
62	SBIR	Closed-Loop Pure Oxygen Static Feed Fuel Cell for Lunar Missions	Distributed Energy Systems	KSC	24	Stephen Szymanski	In order to address the NASA lunar mission, DESC proposes to develop a proton exchange membrane (PEM) closed-loop pure oxygen fuel cell for application to lunar surface exploration, building upon DESC's expertise and fundamental demonstrations in closely related technology. Building upon the Phase I project, the static feed fuel cell hardware will be scaled up approximately three times in active area. The single-cell performance of the larger cell will be compared against the smaller cell. Sub-scale stacks will be tested for durability. The number of cells per stack will be increased as the thermal management and mass transport phenomena permit. Thermal modeling will be conducted to predict the level of heat removal required by scaled-up stacks. Thermal management techniques will be investigated to permit effective scale-up. Flight cell stack and system design will be undertaken at the concept level.
63	SBIR	Autonomous, Cryogenic Leak Detector for Improving Launch Site Operations	Innosense, LLC	KSC	24	Latika Datta	Spaceports, spacecrafts for planetary missions, future projects on the moon and mars ? they all need to monitor mission critical propellants. This project established the feasibility of a tapered optical fiber-based sensor (TOFS) that can be fitted into narrow orifices of plumbing junctions to detect the leakage of cryogenic fluids such as hydrogen. Complete reversibility and response/recovery time of less than 30 seconds for the hydrogen sensor were demonstrated in Phase I. Scanning electron microscope (SEM) images confirmed that the sensor suffered no degradation upon soaking in liquid nitrogen (LN2, 77 K). Tests with LH2 will be conducted in Phase II. The underlying sensor technology will support NASA goal of reducing vehicle and payload cost, and increase safety of operations by measuring hydrogen in real-time and in situ. A prototype device will be engineered, field-tested and delivered to NASA in Phase II establishing technical maturity approaching TRL 6. InnoSense LLC has received a strong endorsement letter from a major Aerospace company in support of the project. InnoSense LLC has also received Phase III follow-on funding commitment totaling $500,000 from commercialization partners. An engineering
64	SBIR	Transmission and Distribution of Photosynthetically Active Radiation (PAR) for Biomass Production in Exploration Missions [7226-270]	Physical Sciences, Inc.	KSC	24	Byron Green	Physical Sciences Inc. (PSI) proposes to develop a plant lighting system which collects, transmits and distributes photosynthetically active radiation (PAR) for biomass production in planetary and transit missions. In this system, solar light or electric lamp light is collected by reflector optics and focused at the end of an optical fiber cable. The light is filtered by a selective wavelength filter to reject the non-PAR spectra to minimize heat generation within the plant growth chamber. The PAR spectra are transmitted to the plant growth chamber where the light is uniformly distributed over the plant growth area at optimum intensities. Key features of the proposed system are: (1) the PAR can be transmitted via a flexible optical fiber cable to plants away from the light source; (2) only the PAR will be transmitted to the plant, minimizing the thermal loading in the plant growth chamber, while the non-PAR spectra can be converted to electricity by means of low band-gap PV cells; (3) the low profile light diffuser makes more volume available for plant growth; and (4) the electric light source can be chosen for the best system efficiency and can be placed at the location best suited for thermal control.

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65	SBIR	Mars Integrated Propellant Production System	Pioneer Astronautics	KSC	24	Robert Zubrin	The Integrated Mars In-Situ Propellant Production System (IMISPPS) is an end-to-end system that will produce rocket propellant on Mars from CO2 in the Martian atmosphere. The IMISPPS conducts both the Reverse Water Gas Shift (RWGS) and Sabatier (S/RWGS) reactions in a single reactor to produce a useful high-specific impulse fuel (methane plus carbon monoxide) and water, which is condensed and electrolyzed to produce oxygen and hydrogen. The hydrogen is recycled back to the S/RWGS reactor to react with fresh Martian CO2 to produce more fuel, while the oxygen is stored to provide oxidizer. Some of the carbon monoxide is removed by cryogenic separation to increase propellant specific impulse. The IMISPPS system produces the correct amount of oxygen to burn the methane produced, almost doubling the leverage of a Sabatier/Electrolysis system alone.
66	STTR	Passive Wireless Hydrogen Sensors Using Orthogonall Frequency Coded Acoustic Wave Devices	Applied Sensor Research & Development Corporation	KSC	24	JacquelineHines	This proposal describes the continued development of passive orthogonal frequency coded (OFC) surface acoustic wave (SAW) based hydrogen sensors for NASA application to distributed wireless hydrogen leak detection systems. These novel sensors use an OFC SAW device structure, combined with Palladium (Pd) nanocluster film elements and hydrophobic self assembled monolayer (SAM) coatings to produce fast, reversible, highly sensitive hydrogen sensors capable of detecting a wide range of hydrogen concentrations at room temperature. The technical feasibility of these sensors was clearly demonstrated in Phase I. The Pd films experience conductivity changes due to the hydrogen induced stretching of the Pd nanoclusters and the quantum nature of conduction in nanocluster films. The performance of the SAW device will change in response to a change in conductivity of this film. Rapid (under 1 second) room temperature detection of hydrogen was observed, with complete reversibility of response. Compatibility of film conductivity with acoustic wave propagation and detection of changes in film conductivity using variations on SAW device delay were confirmed. Manufacturing compatible p
67	SBIR	Modeling, Testing and Deploying a Multifunctional Radiation Shielding / Hydrogen Storage Unit	Advanced Fuel Research Inc	LaRC	34	Michael Sano	This project addresses two vital problems for long-term space travel activities: radiation shielding and hydrogen storage for power and propulsion. While both problems have been studied for many years, there is currently no satisfactory technology for providing adequate non-parasitic shielding. Even in low-Earth orbit, astronauts must be closely monitored for radiation exposure, and some missions simply cannot be performed due to the current inability to adequately shield astronauts (e.g. Mars or surface Lunar bases). The overall objective of the proposed project is to construct, test, and deliver a prototype for hydrogen storage and radiation shielding. In Phase I we experimentally verified the radiation shielding capability of these systems and its ability to operate after being bombarded by ionizing radiation at a nuclear accelerator. In this Phase II proposal, AFR will join with Boeing to design two multi-layer configurations that could be of use for operational missions. We will then work with Prairie View A&M Univ. to perform an empirical study of radiation shielding using NSRL and Loma Linda particle accelerators. In collaboration with Prof. Larry Townsend, we will perform a complementary computational st
68	SBIR	Active Pixel HgCdTe Detectors With Built-in Dark Current Reduction for Near-Room Temperature Operation	EPIR Technologies, Inc.	LaRC	24	Sivalingam Sivananthan	High sensitivity HgCdTe infrared arrays operating at 77K can now be tailored in a wide range of wavelengths from 1 to 14 microns. However, due to the cooling requirements, they consume large amounts of power and are bulky and unsuitable for many NASA applications. During Phase I, we demonstrated the feasibility of employing dark current skimming to increase the operating temperature of HgCdTe mid-wavelength infrared devices to temperature regimes attainable by thermoelectric (TE) cooling. This work will be applied to two-color detectors and 320 ? 256 focal plane arrays during the proposed Phase II effort, leading to the next generation of HgCdTe infrared focal plane arrays. Multicolor detection will involve only an incremental development of the current skimming employed in Phase I. The resistor used in Phase I for skimming will be replaced with a photovoltaic detector that will have two functions: first, it will allow skimming by collecting part of the current flowing through the main detectors, and second, it will act as an independent detector for a second color. By employing a non-equilibrium mode of operation for the same detector, the majority and minority carrier densities will be greatly reduced. Th
69	SBIR	Self-Healing Inflatable, Rigidizable Shelter for the Lunar Environment	Adherent Technologies, Inc.	MSFC	24	Susan Switzer	Any manned missions to extraterrestrial locations will require shelter structures for a variety of purposes ranging from habitat usage to biomass production. Such shelters need to be constructed in such a way to minimize stowed volume and payload weight. The structures must also be very durable and have the ability to survive punctures without collapsing. Ways of increasing available crew-load volume without greatly increasing launch weight or volume are also sought. Inflatable structures are ideal candidates for habitat structures for several reasons: (1) they feature the low stowage volume and payload weight required, (2) deployed volume can be easily increased without large increases in launch weight or volume, (3) they offer unique opportunities for incorporating intelligent and/or multifunctional systems such as self-healing capability, power generation and storage, sensor systems, and radiation protection. Adherent Technologies, Inc. is proposing an inflatable, rigidizable shelter system based on our Rigidization on Command^{TM} (ROC) technology. The proposed shelter system features not only the required low stowage volume and lightweight character, but also feature a self-healin
70	SBIR	Laser Power Transmission Employing a Dual-Use Photovoltaic Concentrator at the Receiving End	ENTECH, Inc.	MSFC	18	Mark O'Neill	The proposed innovation is a wireless laser power transmission system employing a dual-use photovoltaic concentrator at the receiving end. Specifically, the laser receiver/converter employs thin stretched-membrane Fresnel lenses to focus continuous or pulsed laser light onto small photovoltaic cells, thereby reducing cell cost and improving cell conversion efficiency. The dual-use approach can be implemented in several ways, to allow the same photovoltaic concentrator array to be used as a solar array and/or a laser receiver/converter array. Specifically, the photovoltaic concentrator employs multi-junction cells for high-efficiency solar radiation conversion, and single-junction cells for the high-efficiency laser radiation conversion. A prototype lens/cell unit was successfully tested in Phase I, and a more optimal array will be built and tested in Phase II. The new modular laser/solar photovoltaic concentrator will have many NASA, military, and commercial space applications. Applications include spacecraft arrays receiving laser input from other spacecraft or from Earth, lunar or planetary arrays receiving laser input from nearby spacecraft or from Earth, and Earth-based arrays receiving laser input from space so
71	SBIR	Triaxial Swirler Liquid Injector Development	SIERRA ENGINEERING INC.	MSFC	24	Margo Hornung	Sierra Engineering Inc. (Sierra) believes that the subject triaxial liquid propellant swirl injector has the potential to meet many of NASA's Earth-to-Orbit (ETO) propulsion systems goals. The triaxial swirl injector is ideally suited to a wide range of liquid oxidizers and fuels, including hydrogen and a wide range of hydrocarbons. It holds the potential of excellent high-frequency combustion stability characteristics and low injector production cost, similar to a pintle injector. Additionally, the triaxial swirl injector offers the potential for excellent injector and combustion chamber thermal compatibility and outstanding propellant atomization characteristics, both at levels far superior to a pintle injector. The triaxial injector concept is well suited to both main injector and preburner applications. The Phase I SBIR effort focused on understanding the influence design variables have on injector performance. We developed the mechanical design concept for a prototype injector. The proposed Phase II effort will complete the detailed design and analysis of the prototype injector. The test hardware will be fabricated and tested with several propellants. A preliminary design will be developed for a large-scale combustor.
72	SBIR	Silicon Germanium Alloy Photovoltaics for 1.06 Micron Wireless Power Transmission	Structured Materials Industries Inc	MSFC	24	Gary Tompa	Structured Materials Industries, Inc. proposes to develop SiGe photovoltaic technology that matches the Nd:YAG wavelength of 1.06 micron for insertion in future Wireless Power Transmission systems. Full development of the proposed technology will provide NASA with a low-cost, SiGe-based alternative to compound semiconductors. In Phase I of the program we have designed, fabricated and tested a SiGe photocell and demonstrated a 45% external quantum efficiency and a 6% power efficiency at the Nd:YAG wavelength of 1.06 micron. In Phase II we will further optimize the SiGe materials properties and the photocell device structure. In Phase III we will make the SiGe photocells commercially available to NASA's contractors and also market the deposition hardware.

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Renewable Energy Projects

	IPP Source	Project Name	Partner Organization(s)	NASA Center	Duration (months)	Key Contact Person	Project Description
73	SBIR	Methane Pyrolysis for Hydrogen & Carbon Nanotube Recovery from Sabatier Products	Umpqua Research Company	MSFC	24	John Aker	Development of a microgravity and hypogravity compatible catalytic methane pyrolysis reactor is proposed to recover hydrogen which is lost as methane in the conversion of carbon dioxide to water via the Sabatier process. This will close the hydrogen loop which currently requires 50% resupply and also produce carbon nanotubes, a high value product which may be employed as an adsorbent or catalyst for removal of atmospheric trace contaminants, thus further lowering the resupply burden for manned spacecraft. Microgravity compatibility of Gradient Magnetically Assisted Fluidized Beds (GMAFB) has been demonstrated through a series of KC135 flight experiments. Metallic cobalt, which has been fluidized in microgravity using the GMAFB method, is an excellent catalyst for promotion of methane pyrolysis. Recently, fluidized bed catalytic methods have been shown to efficiently recover hydrogen, and produce single walled carbon nanotubes. Using the GMAFB method, this process can be rendered totally compatible with operation in the microgravity of spaceflight or the reduced gravity of planetary environments. By recovering all of the hydrogen which is lost as methane in the Sabatier reactor, the require
74	SBIR	Hydrogen Recovery by ECR Plasma Pyrolysis of Methane	UMPQUA Research Company	MSFC	24	John Aker	Development of a microgravity and hypogravity compatible microwave plasma methane pyrolysis reactor is proposed to recover hydrogen which is lost as methane in the conversion of carbon dioxide to water via the Sabatier process. This will close the hydrogen loop which currently requires 50% resupply. Efficient production of hydrogen from methane was conclusively demonstrated during Phase I using microwave plasmas with power levels ranging between 50 - 120 W. In the plasma reactor, formation and deposition of solid phase elemental carbon was shown to be far less problematic than for current methods of catalytic methane decomposition in fixed bed and fluidized bed reactors. This new technology has strong potential for continuous hydrogen production over extended time periods, with minimal maintenance and operator intervention. Microwave plasmas produce extremely high temperatures localized withi very small volumes, resulting in low overall power requirements. Microwave plasmas also produce minimal thermal effects on downstream piping and other system components. These features provide the basis for a small, light, and low power method for hydrogen reclamation. By recovering all of the hydrogen
75	SBIR	High Efficiency, Easy to-Manufacture Engineered Nanomaterials for Thermoelectric Applications	Voxtel, Inc	MSFC	24	George Williams	Leveraging the successful Phase I SBIR program, a 24-month effort is proposed to optimize and demonstrate a high thermoelectric Figure-of-Merit (ZT) nanocrystal quantum dot (NQD) thermoelectric (TE) material, which will have thermal efficiency properties far better than traditional bulk thermoelectric materials. In the proposed work, a series of TE devices will be fabricated from solidified NQD films formed from colloidally synthesized NQDs using consolidation and second phase precipitation. The increase of ZT, is dependent on quantum confinement of electrons and holes, as well as the phonon dynamics and transport of the materials. If the size of a semiconductor is smaller than the mean free path of phonons and larger than that of electrons or holes, one can reduce thermal conductivity by boundary scattering without affecting electrical transport. Although charge transport in thermoelectricity is almost monoenergetic (energy levels within a few kT around the Fermi energy), heat transport by phonons is broadband over the Brillouin zone. The significance of the opportunity is the ability to colloidally-manufacture, high performance, conformal, thin film TE materials, free from the lattice and other co
76	STTR	High-Speed Thermal Characterization of Cryogenic Flows	Luna Innovations Incorporated	SSC	24	Michael Pruzan	Luna proposes to continue development on a high-speed fiber optic sensor and readout system for cryogenic temperature measurements in liquid oxygen (LOX) and liquid hydrogen (LH2). This work will be based on the solid proof of feasibility completed during the Phase I STTR project and will result in 1) extremely high-speed, minimally-intrusive fiber optic temperature sensors for cryogenic and high-temperature applications and 2) an industrially robust, tum key fiber optic readout system capable of servicing numerous sensor types, addressing a broad range of needs within NASA. The sensors and system developed here will be specifically designed to meet NASA Stennis needs for facility and test article health-monitoring. Additionally, the basic readout system could be extended to include rotary and linear position for valve position feedback, which supports NASA?s stated need for smart system components such as control valves, regulators, and relief valves that provide real-time, closed-loop control, component configuration, automated operation, and component health. Luna?s research subcontractor, Virginia Tech, will develop new and improved methods to accurately model the transient interactior

Questions submitted by Representative Ralph M. Hall

Q1. On many occasions the previous NASA Administrator discussed potential advantages of flying small NASA-research experiments aboard human sub-orbital launch vehicles which are anticipated to be operational within the next few years. It was his belief that this could help reduce the cost of sub-orbital flight research by leveraging the private sector and also bolstering the industry with an additional market, as well as provide a cost-effective way to test micro-gravity research payloads before being launched to the Space Station. This committee has been a longtime supporter of micro-gravity research, and is concerned about reductions in ISS research utilization in the coming years. Last year there was some discussion within NASA as part of the Planning, Programming, Budgeting and Execution (PPBE) process about budgeting approximately $5 million in FY 2010 to establish a Human Sub-orbital Flight Program to enable and conduct scientific research aboard human-tended launch vehicle services. What is the status of this effort, and how much is in the FY 2010 budget for this purpose? Will NASA provide funds this year so scientists can begin developing experiments that could fly once these new vehicles become available?

A1. NASA is studying the use of commercially available, passenger carrying sub-orbital rockets as a science platform, and has created a Human Sub-orbital Flight Program led by the Space Operations Mission Directorate (SOMD). The SOMD will work with service providers as capabilities become available to acquire services to support NASA users selected through a competitive process.

The NASA Science Mission Directorate (SMD) is always interested in any platform that enables science. The SMD has issued multiple calls for Earth and space science investigation ideas. NASA issued two Requests for Information (RFIs) (Feb/Mar 2008; Sep/Dec 2008) seeking expressions of interest in potential NASA science investigations and payloads/experiments taking advantage of the new platforms. The response was low for both RFIs, totaling only six responses suggesting a concept for an Earth or space science investigation (14 responses suggested Exploration Systems Mission Directorate-relevant investigations).

A NASA Research Announcement was issued (Aug/Dec 2008) seeking proposals for funded concept studies in Earth and space science using any capability of the new platforms. Again, the number of responses was low—17 compliant proposals. These were subjected to standard community peer review. Most proposals fared poorly in peer review, rated as poor science or poor use of the platform. The only highly-rated proposal was selected for a one year funded concept study—"Firefly on Demand," PI: Joanne Hill, USRA/GSFC, for study of terrestrial gamma-ray flashes emitted during thunderstorms and their impact on upper atmosphere energetics.

While these efforts have not identified uses for such platforms for the space and Earth sciences, NASA is continuing to explore this concept and the potential benefits it might bring to other areas of research and technology development. Since the vehicles to provide these services are still in various stages of development and testing, it will take time for this activity to mature. NASA is currently assessing the level of resources to be committed to this effort in FY 2010.

Q2. Aeronautics research at NASA has suffered funding reductions over the last ten years. As a consequence, the agency "reshaped" its aeronautics R&D program to do more collaborative, foundational research with industry, other federal agencies, and research institutions. To what degree are industry, research institutions, and other federal agencies collaborating with NASA? It is too soon yet to assess the development and adoption of new technologies under this structure? If so, when will NASA be better able to evaluate its progress?

A2. NASA is very pleased with the degree of collaboration that exists with other government agencies, industry and the academic community. NASA has established strong partnerships with other government agencies and organizations, including the Federal Aviation Administration (FAA), Department of Defense (DOD), and the Joint Planning and Development Office (JPDO). As a member of the National Science and Technology Council (NSTC) Aeronautics Science and Technology Subcommittee, NASA is pursuing a coordinated approach with its government partners to managing and utilizing the Nation's research, development, test, and evaluation (RDT&E) infrastructure, which includes test facilities as well as computational infrastructure. An example of how this partnership is performing is exemplified by the Research Transition Teams that have been established between NASA and the FAA. These teams help ensure that the fundamental research that NASA leads can be effectively transitioned to the FAA and ultimately implemented into the air transportation system.

The Aeronautics Research Mission Directorate (ARMD) NASA Research Announcement (NRA) process has also been very successful. Since 2006, NASA has issued awards for more than 380 research proposals from organizations across the country. These efforts span from focused research topics that involve a few researchers to complex investigations that involve very large teams from industry and academia. A key attribute of the ARMD NRA process is the focus on collaboration. Almost every solicitation promotes collaboration and encourages external researchers to propose work that is collaborative with NASA researchers. Because of this focus, very few grants have been issued. Instead, there is a large proportion of cooperative agreements that are utilized because of the close interactions between NASA and external personnel.

In addition to funded activities, NASA is engaged in a number of non-reimbursable space act agreements with industry partners. ARMD has established more than 68 of these Space Act Agreements since 2006. While these collaborative efforts are important for advancing the aeronautics technologies, they are also important mechanisms to facilitate the transfer of knowledge between NASA and U.S. industry.

NASA utilizes the "N+1, N+2, and N+3" notation to indicate the generation of aircraft that are expected to primarily benefit the long-term cutting edge research that is conducted today. There is a significant focus on technologies for the N+2 generation of aircraft which are expected to enter service around 2025–2030. Therefore, there is not an expectation that much of this research will be adopted today. In fact, the development timelines for aircraft are so long that it is unlikely that many of the technologies be developed by NASA today will be implemented on the next generation of civil transports. However, NASA has established challenging goals for future systems and is making the high risk investments today that are needed to realize such profound improvements in capabilities in the future. ARMD has refrained from establishing definitive transition metrics because these tend to promote the development of more incremental technologies. Instead the focus is on enabling significant improvements to capabilities. If successful these will be adopted and will make a difference. The ARMD portfolio is quite broad, and while most technologies will not be implemented in the near future, there are examples where some technologies may make a difference in the near-term. For example, as a result of collaboration under the NRA process, a new scheduling tool has been developed that is estimated to save approximately $2.8M per year for airlines operating into San Francisco.

Q3. The budget establishes a new Integrated Systems Research Program within the Aeronautics Directorate. What is the role of this program, and to what degree will it be able to validate or demonstrate promising technologies?

A3. The Integrated Systems Research Program (ISRP), a new $62.4M program effort beginning in FY 2010, will conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment. The integrated system-level research in this program will be coordinated with on-going long-term, foundational research within the three other research programs, and will focus specifically on maturing and integrating technologies in major vehicle and operational systems and subsystems for accelerated transition to practical application.

The goal of the first project in ISRP, the Environmentally Responsible Aviation project, is to explore and document the feasibility, benefits, and technical risks of vehicle concepts and enabling technologies identified to have the potential to mitigate the impact of aviation on the environment. Through system-level analysis, promising vehicle and propulsion concepts and technologies will be down-selected based on their potential benefit towards simultaneously reducing fuel burn, noise and emissions. NASA will provide much more informed trade space with validation in relevant environments for the selected concepts and technologies by 2015, so that industry can accelerate the introduction of these promising ideas in future product development.

Q4. What provisions does NASA have in place if the two COTS contractors are not able to develop their launch systems in time to meet ISS cargo requirements by 2012? How will the void of cargo services be filled?

A4. In the post-Shuttle era, the ISS will be supplied by domestically developed commercial cargo services under the Commercial Resupply Services (CRS) contract, the Russian Progress, the European Automated Transfer Vehicle (ATV), and the Japanese H–II Transfer Vehicle (HTV). NASA is relying on U.S. industry to develop cargo transportation capabilities that will be able to support the ISS and intends to purchase cargo transportation from the U.S. commercial market. The major uncertainty will be the schedule. The contracts are fixed price with milestone driven payments. The total cost will be fixed but the payment schedule will vary. NASA

realizes that the commercial industry is evolving, and choosing two CRS providers increases the probability of success of commercial ISS resupply services. While international partners' vehicles do provide some capabilities, it remains vital to the full utilization of the ISS that the CRS contractors attain the capability of supporting the Space Station's full, six-person crews in the future.

Q5. What do you consider the three highest technical risks to maintaining the Ares I and Orion IOC, and what steps are being taken to address them? Include details of how the $630M provided by the Recovery Act will be allocated within the program to reduce schedule and programmatic risk.

A5. NASA has identified clear mitigation strategies for the key technical challenges that have been identified, such as those listed below. All launch vehicle development efforts encounter technical challenges as the design evolves. This is part of the design process and normal engineering practices. As such, NASA is actively working these risks, and has made great progress in mitigating many of them.

- *Ares I Thrust Oscillation:* Thrust oscillation is a characteristic within solid rocket motors based on internal geometry. Early Ares I structural analyses indicated that thrust oscillation, unless corrected, could result in high dynamic G force levels in the upper stage and the Orion. This is not an uncommon problem in solid rocket motors. In November 2007, NASA chartered the Thrust Oscillation Focus Team to precisely define the frequency spectrum and oscillation amplitudes that the five-segment motor is expected to produce. The team's analysis has led to several mitigation strategies, including propellant dampening, spring isolator concepts, and an aft skirt tuned vibration absorber. The team's final analysis and recommendations for incorporation of thrust oscillation mitigation designs will be presented during the Constellation Preliminary Design Review, which is scheduled to begin late this year and continue through early next year.
- *Orion Mass:* Orion, like all spacecraft, has a mass limit, and will not be able to accomplish its mission if it goes over it. The Orion team continues to refine its design and has made several changes that reduce the overall spacecraft mass. For example, the power distribution system was redesigned to a distributed system configuration achieving considerable mass reduction. Also, a passive loads attenuation system for contingency land landing was selected, thereby eliminating the weight of an airbag system.
- *Common bulkhead manufacturing risk:* The common bulkhead was employed to reduced mass of the upper stage, but has a complex manufacturing process. The Ares Project continues to perform subscale and full scale testing of manufacturing and inspection techniques for the common bulkhead to mitigate any development risks.

With regard to the second question about funding, the President's FY 2010 budget request for Exploration Systems is $3.963B, an increase of $457.6M above the FY 2009 appropriation and $225.4M above the planned FY 2010 level in last year's request. Based on the $400M in Recovery Act funds and the increase in the FY 2010 President's budget request over last year's levels, the Exploration Systems budget plan includes about $630M more in FY 2009 and FY 2010 than the previous plan. The $400M in Recovery Act funds for Exploration Systems includes $310M which will be applied to Constellation Systems and $90M which will be applied toward the Commercial Crew and Cargo Program.

Pending potential changes due to the results of the Review of U.S. Human Spaceflight plans, the Recovery Act funding for Constellation Systems will be allocated to critical activities related to the successful completion of the Orion, Ares I and Ground Operations projects. The Constellation Program plans to use the funds to accelerate its test schedule and the procurement of long-lead items, thereby mitigating risk. More specifically, the funding will:

- Increase fidelity in the Orion Ground Test Article providing better understanding of the loads environment and reducing risk as the Project moves forward with design. Additional risk reduction is provided by tasks that will demonstrate and test materials and spacecraft systems to better understand the potential failure limits. Overall schedule risk reduction is being accomplished through use of the Recovery Act funds for Orion Engineering Development Units and efforts to begin Long Lead Procurement activities earlier.
- Design the specialized systems and equipment for the Mobile Launcher, which are a critical part of the overall structure. The Mobile Launcher is a large platform with a tower used to transport, service, and launch the next generation launch vehicle and spacecraft (Ayes I and Orion).

- Accelerate development of J–2X engine components.
- Develop Ares Upper Stage tooling for common bulkhead and the Upper Stage Vertical Assembly Tool.
- Development and outfitting A–3 test stand.

The remaining $90M will support plans to stimulate efforts to develop and demonstrate technologies that enable commercial human space flight capabilities. These efforts are intended to foster entrepreneurial activity leading to job growth in engineering, analysis, design, and research, and to economic growth as capabilities for new markets are created. It is important to note that some of these funds will support the commercial space industry as well as the Constellation Program. A portion of the funds will be used for competitive awards for commercial development of crew concepts and technology demonstrations and investigations. A portion of the funds will be used to accelerate an International Space Station docking interface that could be utilized by both the commercial space community as well as the Orion project. A portion of the funds will support investments in launch site and test infrastructure at various Centers that will benefit both government and commercial interests. A portion of the funds will be used for human rating requirements development that will be applicable to the Constellation Program as well as commercial partners, and will reduce the complexity associated with human rating a space flight system.

Q6. Last year, GAO issued a report suggesting that NASA had not adequately budgeted for Shuttle transition and retirement costs. The FY 2009 Omnibus Appropriations Conference Report included language directing the agency to better define these costs and incorporate them into future budget requests. The FY 2010 budget request includes $47.1M in FY 2011 and FY 2012 for Shuttle transition and retirement costs. Although that figure is higher than the $96M proposed in last year's budget, it is still low compared to NASA's previous estimate of $1.2B. Given the costs associated with contract closeouts, employee retention or termination, disposition or transition of real property and flight qualified hardware, as well as other costs associated with such a large, geographically diverse program, what has changed that permits NASA to achieve these savings? Please provide a breakdown of how the $471 million will be spent.

A6. NASA has been transitioning from the Space Shuttle Program to the next generation of human space flight vehicles since 2005. Each time the Agency has refined its Transition and Retirement (T&R) cost projections, they have decreased. In large part, this is due to an increasing understanding of all of the elements of this undertaking; NASA has not retired a major human space flight system since the mid-1970s, and the Space Shuttle is far more complex than its predecessors. In addition, the Agency continues to find ways to put Shuttle assets to effective use in the Constellation Program, further reducing T&R costs.

The President's Budget Request for FY 2010 includes $470.6M in the Space Shuttle Program for T&R activities for FY 2011 and 2012. This funding is to be allocated as below (numbers do not add to $470.6M due to rounding).

- $114.3M—Personal Property
- $49.7M—Major Flight Assets
- $55.6M—Real Property
- $11.2M—Records Management
- $2.0M—Software Disposition
- $55.7M—Contract Closeout
- $44.2M—Oversight and Integration
- $42.3M—Civil Service Labor and Travel
- $95.7M—Severance and Retention

Q7. What does this budget assume with regard to Shuttle retirement, especially with regard to personnel actions, schedule, and facilities? What are NASA's plans for the actual disposition of the Orbiters and other flight and ground artifacts of the Shuttle program?

A7. The President's Budget Request for FY 2010 supports Shuttle operations through the end of FY 2010; there is currently no funding to support flights beyond FY 2010, though the Agency plans to fly out the remaining missions even if the manifest slips. The decision has been made by the Administration to fly the remaining International Space Station assembly flights, including the Alpha Magnetic

Spectrometer flight, while supporting the goal to fly the Space Shuttle safely as possible until its retirement, which we believe can be accomplished by the end of 2010.

The Space Shuttle Program is now moving forward with the retirement plans previously established and notified to Congress. This includes plans to transition workforce from the Shuttle program to follow-on efforts where possible, as well as plans to utilize Shuttle facilities, where appropriate, to support such efforts. NASA provides updates to its *Workforce Transition Strategy* twice a year to ensure that Congress is kept informed of the Agency's personnel transition activities. In November 2008, the Agency reported to Congress on efforts to disposition the Shuttle Orbiters and related artifacts in the *Space Shuttle Program Transition and Retirement Personal Property Disposition Plan*. On December 17, 2008, NASA issued a "Request for Information" (RFI) to obtain market research from educational institutions, science museums, and other appropriate organizations regarding the community's ability to acquire and display a Space Shuttle Orbiter. NASA received about 20 responses to the RFI, which closed on March 17, 2009. The responses will inform the development of strategies for placement of the Orbiters anti Space Shuttle Main Engines after conclusion of the Space Shuttle Program.

Q8. Many of NASA's science missions have been launched on the Boeing Delta 11, which has proven to be one of the most reliable rockets ever built. Unfortunately, production of Delta 11's is coming to an end. How will this impact the cost of launching future science missions? What steps is NASA taking to ensure continued access to an affordable, reliable medium-lift launcher? What would be the cost impact if NASA were to purchase launchers provided by the United Launch Alliance (Delta 4 and Atlas 5)?

A8. NASA's strategy for providing domestic commercial launch services in support of NASA's medium-class missions is linked to the International Space Station (ISS) Commercial Resupply Services (CRS) contracts that were awarded on December 23, 2008. The CRS vendors are developing vehicles that could be available for medium-class NASA science missions on a NASA Launch Services (NLS)-type contract, for potential launches in the 2013–2014 timeframe. At this time, the CRS launch vehicles are in an early stage of development, and have not yet been demonstrated. This will establish a larger business base for medium-class launch vehicles, which should help reduce launch prices for NASA's space and Earth science missions in this class.

However, it is important to note that the CRS providers are not currently developing the full range of capabilities (e.g., high inclination launch site, upper stage for Earth escape missions, Dual Payload Attach Fitting) typically utilized by NASA science missions. Therefore, some additional costs will be incurred to fully meet NASA's science needs. NASA has not yet finalized the funding estimate for these capabilities, but the contract(s) which follows NLS will be used to definitize service options to meet NASA's science needs.

NASA provided more information on the state of small- and medium-class launch vehicles in its report to the Committee on the topic, delivered in August 2009.

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