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Statement of
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before the

Committee on Science and Technology
U.S. House of Representatives

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear today to discuss the President's FY 2011 budget request for NASA. NASA is grateful for the support and guidance received from this Committee through the years and looks forward to working with you on enactment of the President's bold new direction.

The President's FY 2011 budget request for NASA is $19.0 billion, which represents an increase of $276.0 million above the amount provided for the Agency in the FY 2010 Consolidated Appropriations Act (P.L. 111-117), and an increased investment of $6.0 billion in NASA science, aeronautics, human spaceflight and enabling space technologies over the next five-years compared with last year's budget plan. Enclosure 1 displays the details of the President's FY 2011 budget request for NASA.

Before I discuss the details of the NASA budget request, I would like to talk in general about the President's new course for human exploration of space. Our mission is to develop the required technology, knowledge and infrastructure to sustainably extend human presence throughout the solar system. NASA's exploration efforts will focus not just on our moon, but also on near-earth asteroids, strategic deep space zones called Lagrange points, and the planet Mars and its moons. For me, the ultimate destination in our solar system at present is Mars. While we cannot provide a date certain for the first human visit, with Mars as a key long-term destination we can identify missing capabilities needed for such a mission and use this to help define many of the goals for our emerging technology development.

Let me pause here for a moment to emphasize that we need the new capabilities and knowledge we are developing, not to perfect our approach to spaceflight, but to enable even the most basic of missions. For example, if you gave NASA unlimited resources today, we could not take a human safely to Mars in the near future, because we have not solved the interrelated problems of shielding humans from radiation in space, providing consumables to last the distance, and constructing a rocket to take all of those items into space.

Over the next several years, NASA will build technologies and infrastructure to enable safe human exploration at a more sustainable rate. If done properly, the United States and its partners will be able to send human missions beyond low earth orbit more safely, more-cost-effectively, and more capably than currently conceived.

First, we will extend the life of the International Space Station (ISS), likely to 2020 or beyond. The unique laboratory environment of the ISS will provide answers to key questions about human survivability in space and provide the environment to test critical enabling technologies to benefit life on Earth as well as enhance our ability to venture to destinations such as Mars, the Moon, and asteroids.

We will also encourage and support private sector investment in space. NASA has already invested in the private sector to transport *cargo* to the ISS. Two companies are making great progress, and we hope in the next few months to have the first demonstration of the Falcon 9 that will serve as the launch vehicle for the SpaceX system. The FY 2011 budget also includes a $6 billion, five-year investment in *crew* transport to the ISS by a broad range of private companies. When successful this will expand the utilization of not only the ISS but also near Earth space to a greater segment of society.

Several years from now, when we have developed some of the critical technologies we need to explore safely and effectively, when our robotic precursor missions have scouted out the most interesting sites for human exploration, when our international partners have worked with us to develop new exploration architectures with shared costs and benefits, then we will be ready to press the accelerator for human missions into the solar system. Our goal will be then, as it is now, to create a lasting human space-faring capability for our nation, and with our international and commercial partners, for the World. Now let me turn to describe the FY 2011 NASA budget request in detail.

Highlights of the FY 2011 Budget Request

The President has laid out a bold new path for NASA to become an engine of innovation, with an ambitious new space program that includes and inspires people around the world. Beginning in FY 2011, the United States will pursue a more sustainable and affordable approach to human space exploration through the development of transformative technologies and systems. As the Constellation Program is ended in an orderly manner, NASA will encourage the development of commercial human spaceflight vehicles to safely access low-Earth orbit and will develop new technologies that will lay the foundation for a more exciting, efficient and robust U.S. human exploration of the solar system than we are currently capable of, while further strengthening the skills of our workforce and our Nation in challenging technology areas. NASA will also invest increased resources in climate change research and observations; aeronautics research and development (R&D), including green aviation; space technology development of benefit across the entire space sector; and education with an emphasis on Science, Technology, Engineering and Mathematics (STEM) learning.

Here is a broad outline of the FY 2011 budget plan followed by more details. In FY 2011, NASA will undertake:

- Transformative technology development and demonstrations to pursue new approaches to human spaceflight exploration with more sustainable and advanced capabilities that will allow Americans to explore the Moon, Mars and other destinations. This effort will include a flagship demonstration program, with international partners, commercial and other government entities, to demonstrate critical technologies, such as in-orbit propellant transfer and storage, inflatable modules, automated/autonomous rendezvous and docking, closed-loop life support systems, and other next-generation capabilities. It will also include projects that are smaller and shorter-duration, which will demonstrate a broad range of key technologies, including *in-situ* resource utilization and advanced in-space propulsion.

- Heavy-lift propulsion research and development that will investigate a broad scope of R&D activities to support next-generation space launch propulsion technologies, with the aim of reducing costs and shortening development timeframes for future heavy-lift systems for human exploration.

- Robotic precursor missions to multiple destinations in the solar system in support of future human exploration, including missions to the Moon, Mars and its moons, Lagrange points, and nearby asteroids.

- Significant investments for the development of commercial crew and further cargo capabilities, building on the successful progress in the development of commercial cargo capabilities to-date. NASA will allocate these funds through competitive solicitations that support a range of higher- and lower-programmatic risk systems and system components, such as human-rating of existing launch vehicles and development of new spacecraft that can ride on multiple launch vehicles.

- Extension of the lifetime of the International Space Station (ISS), likely to 2020 or beyond, in concert with our international partners, with investments in expanded ISS utilization through upgrades to both ground support and onboard systems and use of the ISS as a National Laboratory.

- Pursuit of cross-cutting Space Technology capabilities, led by the newly established Office of the Chief Technologist, which will fund advancements in next-generation technologies, to help improve the Nation's leadership in key research areas, enable far-term capabilities, and spawn game-changing innovations that can unlock new possibilities and make space activities more affordable and sustainable. A NASA focus on innovation and technology will enable new approaches to our current mission set and allow us to pursue entirely new missions for the Nation.

- Climate change research and observations, which will enable NASA to substantially accelerate and expand its Earth Science capabilities, including a replacement for the Orbiting Carbon Observatory, development of new satellites recommended by the National Academy of Sciences Decadal Survey, and development of smaller Venture class missions. This investment will ensure the critically important continuity of certain key climate measurements and enable new measurements to address unknowns in the climate system, yielding expanded understanding of our home planet and improved understanding of climate change.

- Aeronautics research and development, including critical areas of the Next Generation Air Transportation System, environmentally responsible aviation, and safe integration of unmanned aircraft systems into the national airspace.

- Education initiatives, including the recently announced Summer of Innovation pilot program involving NASA scientist and curricula to inspire middle-school students and their teachers with exciting experiences that spur those students to continue in STEM careers.

I wish to emphasize that NASA intends to work closely with the Congress, including this Committee, to make a smooth transition to the new Exploration program, called for in the President's request, working responsibly on behalf of the taxpayers. With my deepest gratitude, I commend the hard work and dedication that thousands of NASA and contractor workers have devoted to Constellation over the last several years. Their commitment has brought great value to the Agency and to our Nation, and they will continue to play a pivotal role in NASA's future path. Many of the things NASA has learned from the Constellation program will be critical as the Agency moves forward.

The following contains more detail on the summary points made above, in the standard budget order for NASA's appropriation accounts.

Science

The President's FY 2011 request for NASA includes $5,005.6 million for Science. The NASA Science Mission Directorate (SMD) continues to expand humanity's understanding of our Earth, our Sun, the solar system and the universe with 59 science missions in operation and 30 more in various stages of development. The Science budget funds these missions as well as the research of over 3,000 scientists and their students across our Nation. The recommendations of the National Academies/National Research Council (NRC) decadal surveys help to guide SMD in setting its priorities for strategic science missions; and SMD selects competed missions and research proposals based on open competition and peer review.

The FY 2011 budget request for Science includes $1,801.7 million for **Earth Science.** This request increases investment in Earth Science by $1.8 billion from FY 2011 to FY 2014 compared to the FY 2010 budget, for a more aggressive response to the challenge of climate change. NASA will rapidly develop an Orbiting Carbon Observatory-2 mission for launch early in 2013 and a GRACE Follow-On mission for launch in late 2015, respectively, to initiate and extend key global climate data sets. This request accelerates several high-priority Decadal Survey missions that will advance climate research and monitoring. The increased funding accelerates launch of the Soil Moisture Active/Passive (SMAP) mission by six months from its estimated date at the recent Agency Key Decision Point (KDP)-B review, to November 2014. ICESAT-2 is advanced by five months relative to the estimated date at its recent Agency KDP-A review, to October 2015. The Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission and the Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) mission are each accelerated by two years, with both launching in late 2017. Thus, the budget request allows all four Tier-1 Decadal Survey missions to be launched between 2014 and 2017. In addition, NASA—working with the U.S. Global Change Research Program—will be able to identify and begin development for accelerated launch of selected Tier-2 Decadal Survey missions focused on climate change. The budget supports critical continuity of climate observations, including a Stratospheric Aerosol and Gas Experiment III (SAGE III) instrument to be developed for deployment on the ISS, while also supporting an accelerated pace of smaller "Venture class" missions. Finally, increased resources for Earth Science will allow NASA to expand key mission-enabling activities, including carbon monitoring, technology development, modeling, geodetic ground network observations, and applications development including the highly successful SERVIR program.

At present, NASA Earth-observing satellites provide the bulk of the global environmental observations used for climate change research in the United States and abroad. This year, analyses of NASA satellite measurements quantified the rates of ground water depletion since 2003 in California and in India's Indus River valley—rates that are unsustainable for the future. NASA conducted the first ICEBridge airborne campaigns in both Arctic and the Antarctic, to maintain the critical ice measurements during the gap in time between the ICESAT-1 and -2 satellites.

In FY 2011, the Glory and Aquarius missions will launch; and FY 2011 should close with the launch of the NPOESS Preparatory Project. The Landsat Data Continuity Mission will complete spacecraft integration and test, the Operational Land Imager will be delivered, and the Thermal Infrared Sensor will continue development. The Global Precipitation Mission will complete its System Integration Review in preparation for the beginning of assembly, integration and testing. During FY 2011, the SMAP mission will transition from formulation to development, and ICESAT-2 will begin design. Also in FY 2011, instrument development and observations initiated under the first Venture class solicitation for sustained

airborne missions will reach full funding, and the next Venture class solicitations will be released—this time for space-based mission instrument, and complete mission, developments. Engineering studies and focused, actively-managed technology investments – instruments, components, and information systems – continue for the suite of future missions recommended by the National Research Council (NRC) Decadal Survey. In FY 2011, the Earth Science Technology Program will make additional, competitively-selected, instrument technology investments to meet decadal survey measurement goals. Earth Science Research and Applied Sciences Programs will continue to employ satellite observations to advance the science of climate and environmental change, mitigation, and adaptation. NASA will demonstrate the use of Uninhabited Aerial Systems in field campaigns addressing atmospheric trace gas composition and hurricane genesis, and NASA's modeling and data analysis efforts will contribute to assessment activities of the Intergovernmental Panel in Climate Change and the U.S. Global Change Research Program.

The FY 2011 budget request for Science includes $1,485.8 million for **Planetary Science**. The current NASA planetary missions continue to make new discoveries and return fascinating images, including a previously unknown large and askew ring of Saturn and a near-complete map of the surface of Mercury. Mars continues to intrigue with signs of water ice just below the surface at mid-latitudes. The Mars rover Spirit is now an *in situ* science prospector, while Opportunity continues to roll toward the crater Endeavor. The Moon Mineralogy Mapper instrument on India's Chandrayaan-1 mission detected small amounts of water and hydroxyl molecules at unexpectedly low latitudes on the lunar surface. NASA selected three new candidate mission concepts for further study under the New Frontiers program, and will select the winning concept in FY 2011 to proceed to development. NASA will issue its next Discovery Announcement of Opportunity this year, and will select mission concepts and fund concept studies in FY 2011. NASA will also begin Advanced Stirling Radioisotope Generator development in FY 2011 to be available as an option to improve the performance of the radioisotope-fueled power sources for use in the next Discovery mission. The Mars Science Laboratory will complete development in FY 2011 for launch in fall 2011, beginning the most comprehensive astrobiology mission to the Red Planet to date. The MAVEN Mars aeronomy mission will continue development for launch in late 2013. NASA will establish a joint Mars Exploration Program with the European Space Agency (ESA) with a trace gas orbiter mission, including a European technology demonstration lander. In FY 2011, NASA plans to select instruments for the mission via a joint Announcement of Opportunity. To advance scientific exploration of the Moon, NASA will launch the GRAIL mission in late 2011 and continue development of LADEE for launch in 2013. Continuing its exploration of the outer planets, NASA will launch the Juno mission to Jupiter in August 2011. NASA will continue studies that support the possibility of a new major Outer Planets Mission concept pending the outcome of the NRC decadal survey now in progress, and will coordinate with ESA on a solicitation for science instruments. The new NRC Decadal Survey in Planetary Science should be complete in FY 2011. The FY 2011 budget request increases NASA's investment in identification and cataloging of Near Earth Objects and, with the Department of Energy, begins funding the capability to restart Plutonium-238 production here in the United States.

The FY 2011 budget request for Science includes $1.076.3 million for **Astrophysics**. The golden age of Astrophysics from space continues, with 14 observatories in operation. Astrophysics research, technology investments, and missions aim to understand how the universe works, how galaxies, stars and planets originated and developed over cosmic time, and whether Earth-like planets -- and possibly life -- exist elsewhere in the cosmos. The NASA Kepler telescope has discovered five exoplanets, ranging in size from Neptune to larger than Jupiter, demonstrating that the telescope is functioning as intended; additional discoveries are anticipated in the coming months and years. NASA's newest space observatory, WISE (Wide-Field Infrared Explorer), has captured its first look at the starry sky and its sky survey in infrared light has begun. Radio astronomers have uncovered 17 millisecond pulsars in our galaxy by studying unknown high-energy sources detected by the Fermi Gamma-ray Space Telescope.

The Hubble Space Telescope is operating at its peak performance thanks to the very successful servicing mission last year by the STS-125 crew. The Herschel and Planck missions, led by the European Space Agency with NASA as a partner, launched in 2009 and are returning remarkable scientific results. In FY 2011, NASA will complete most of the development of the NuSTAR mission and prepare it for launch. NASA will also begin developing the Gravity and Extreme Magnetism (GEMS) mission recently selected in the Explorer small satellite program. The James Webb Space Telescope (JWST) continues to make good progress in development toward a 2014 launch. Flight hardware for the many JWST subsystems is being designed, manufactured and tested, including the 18 segments of its 6.5-meter primary mirror; and the mission-level Critical Design Review for JWST will occur this spring. The SOFIA airborne observatory successfully conducted its first open-door flight test in December 2009—a major milestone toward the beginning of early science operations this year. The NRC is conducting a new Decadal Survey in astronomy and astrophysics, which will set priorities among future mission concepts across the full spectrum of Astrophysics, including dark energy, gravity wave, and planet-finding missions; the "Astro2010" Decadal Survey is expected in September.

The FY 2011 budget request for Science includes $641.9 million for **Heliophysics**. The Heliophysics operating satellites provide not only a steady stream of scientific data for the NASA research program, but also supply a significant fraction of critical space weather data used by other government agencies for support of commercial and defense activities in space. These data are used for operating satellites, optimization of power transmission networks, and supporting communications, aviation and navigation systems. The NASA Aeronomy of Ice in Mesosphere (AIM) satellite has provided the first comprehensive, global-scale view of the complex life cycle of Earth's highest clouds, Polar Mesospheric Clouds, finding clues to why they appear to be occurring at lower latitudes than ever before. The STEREO B spacecraft recently observed a sunspot behind the Sun's southeastern limb—before it could be seen from Earth. In a few days, this sunspot produced five Class M solar flares of the kind that disturb radio signals on Earth, signaling the end of the Sun's extended quiet period of recent years. The Solar Dynamic Observatory (SDO), launched on February 11, will provide images of the Sun of unprecedented resolution, yielding new understanding of the causes of solar variability and its impact on Earth. In FY 2011, the Radiation Belt Storm Probes mission will complete hardware manufacturing and begin integration and testing. The Solar Orbiter Collaboration with the European Space Agency will continue in formulation, and the Solar Probe Plus mission will undergo an initial confirmation review at the end of FY 2011. The Magnetospheric Multi-scale mission will continue development toward a Critical Design Review. IRIS, a recently selected small Explorer mission, will hold its Critical Design Review in FY 2011. The next Explorer Announcement of Opportunity will be released in 2010, with selection for Phase A studies in FY 2011. NASA is working with the NRC to arrange for the next decadal survey in Heliophysics.

Aeronautics Research

The U.S. commercial aviation enterprise is vital to the Nation's economic well-being, directly or indirectly providing nearly one million Americans with jobs. In 2008 aerospace manufacturing provided the Nation with a trade surplus of over $57 billion. In the United States, more than 60 certified domestic carriers operate more than 28,000 flights daily, moving nearly one million travelers each day. We expect these flights to be safe, affordable, and convenient. We expect airlines to offer flights when and where we want to travel. In business and in our personal lives, the aviation industry is a key enabler to our way of life and the smooth functioning of our economy. However, the air transport system is near maximum capacity given today's procedures and equipment. Rising concerns about the environmental and noise impacts of aviation further limit future growth.

The FY 2011 budget request for Aeronautics is $579.6 million, an increase of $72.6 million, which will strongly support our existing portfolio of research and development to directly address these most critical needs of the Nation and enable timely development of the Next Generation Air Transportation System (NextGen). Through a balanced research and development portfolio, NASA's Aeronautics Research Mission Directorate (ARMD) is exploring early-stage innovative ideas, developing new technologies and operational procedures through foundational research, and demonstrating the potential of promising new vehicles, operations, and safety technology in relevant environments. Our goals are to expand capacity, enable fuel-efficient flight planning, reduce the overall environmental footprint of airplanes today and, in the future, reduce delays on the ground and in the sky, and improve the ability to operate in all weather conditions while maintaining the current high safety standards we demand.

The FY 2011 budget request for Aeronautics includes $228.5 million for the **Fundamental Aeronautics Program**, which seeks to continually improve technology that can be integrated into today's state-of-the art aircraft, while enabling game-changing new concepts such as Hybrid Wing Body (HWB) airframes which promise reduced drag (thus improving fuel burn) and open-rotor engines which offer the promise of 20 percent fuel burn reduction compared to today's best jet engines. In partnership with Boeing and the Air Force, NASA has completed over 75 flights of the X48B sub-scale HWB aircraft at Dryden Flight Research Center in the last two years to explore handling and control issues. NASA is partnering with General Electric and Boeing to evaluate performance and integration of new open-rotor engine concepts in propulsion wind tunnels at the Glenn Research Center. NASA is also addressing key challenges to enable new rotorcraft and supersonic aircraft, and conducting foundational research on flight at seven times the speed of sound. American Recovery and Reinvestment Act funds have enabled NASA to re-commission a full-scale airframe structural test facility and to improve wind tunnels at the Langley, Ames, and Glenn Research Centers that are needed to assess new concepts that hold the promise of significant reductions in aircraft weight and fuel consumption. In partnership with industry, NASA has just initiated the first new government-funded effort on low NOx combustors in 15 years. In FY 2011, NASA will invest $30.0 million to design, build, and demonstrate a new generation of aircraft engine combustors that will lower the emission of harmful nitrogen oxides by 50 percent compared with current combustors while ensuring compatibility with current and future alternative aviation fuels.

A key research goal is to develop synthetic and bio-derived alternatives to the petroleum-derived fuel that all jet aircraft have used for the last 60 years, but little is known about the emissions characteristics of these alternative fuels. In 2009, NASA led a team of eight partners from government agencies, industry, and academia in measuring emissions from an aircraft parked on the ground operating on various blends of synthetic and standard jet fuel. This team discovered that synthetic fuel blends can reduce particulate emissions by as much as 75 percent compared to conventional jet fuels, which would offer a major improvement in local air quality around airports. Using results from this and other research efforts, NASA has established a publicly-available database of fuel and emissions properties for 19 different fuels and will perform similar tests on biofuels as they become available.

The FY 2011 budget request for Aeronautics includes $82.2 million for **Airspace Systems**. The focus of this program is to achieve reductions in environmental impact not only through new aircraft, engines, and fuels, but also through improved air traffic management procedures. Using flight data from just the top 27 airports in the country, NASA systems analysis results indicate that nearly 400 million gallons of fuel could be saved each year if aircraft could climb to and descend from their cruising altitude without interruption. Another 200 million gallons could be saved from improved routing during the cruise phase of flight. Achievement of such operations requires that aircraft spacing in the air and on-time arrival and departure from the regions around our major airports be greatly improved. New satellite-based navigation aids such as the ADS-B system that the Federal Aviation Administration (FAA) is installing throughout the country can enable these improvements, but safe and efficient operational procedures must first be developed, validated, and certified for operational use. In 2009, NASA partnered with FAA, United

Airlines, and Air Services Australia to validate pilot and controller procedures for a new concept originally developed by NASA that enables aircraft to safely conduct climbs and descents outside radar coverage in close proximity to nearby traffic. NASA also provided safety analyses needed for regulatory approval. The procedures benefit both airlines and the traveling public by providing long-haul oceanic flight with easier access to fuel-efficient, turbulence-free altitudes. United Airlines is expected to begin flying the oceanic in-trail procedures on revenue flights in May 2011.

The FY 2011 budget request for Aeronautics includes $113.1 million for the **Integrated Systems Research Program.** Begun in FY 2010, this program evaluates and selects the most promising "environmentally friendly" engine and airframe concepts emerging from our foundational research programs for integration at the systems level. In FY 2011, the program will test integrated systems in relevant environments to demonstrate that the combined benefits of these new concepts are in fact greater than the sum of their individual parts. Similarly, we are integrating and evaluating new operational concepts through real-world tests and virtual simulations. These efforts will facilitate the transition of new capabilities to manufacturers, airlines and the FAA, for the ultimate benefit of the flying public. In addition to strongly supporting our ongoing research portfolio, the FY 2011 budget request includes increased funding to expand our research in new priority areas identified through close consultation with industry, academia and other federal agencies. In FY 2011, NASA will initiate a $30 million targeted effort to address operational and safety issues related to the integration of unmanned aircraft systems into the National Airspace System and augment research and technology development efforts by $20 million, including grants and cooperative agreements, to support NASA's environmentally responsible aviation research.

The FY 2011 budget request for Aeronautics includes $79.3 million for the **Aviation Safety Program.** This program conducts research to insure that aircraft and operational procedures maintain the high level of safety which the American public has come to count on. Safety issues span aircraft operations, air traffic procedures, and environmental hazards and this program is supporting research and delivering results in all three areas. American carriers operate 6,500 aircraft on more than 28,000 flights daily. For most of the day the FAA is controlling more than 4,000 aircraft in the sky at the same time. Further increases in capacity will require increased levels of automation for command and control functions and to analyze vast amounts of data, as well as increased complexity of the overall system. It now costs more to prove today's flight-critical systems are safe than it does to design and build them. The Joint Planning and Development Office has identified Verification and Validation (V&V) of aviation flight-critical hardware and software systems as one of the major capability gaps in NextGen. Therefore in FY 2011, NASA is initiating a new $20 million research activity in V&V of aviation flight-critical systems to develop methodologies and concepts to effectively test, validate and certify software-based systems that will perform reliably, securely, and safely as intended.

NASA will continue to tackle difficult issues that threaten the safety of commercial flight, ranging from human/machine interaction to external hazards such as weather and icing, as the aircraft industry has come to rely on NASA expertise in predicting the effects of icing on aircraft performance at low and intermediate altitudes. However, over the last 10 years a new form of icing problem has surfaced, occurring primarily in equatorial regions at high cruise altitudes and causing engine power loss or flameout. These conditions cannot be duplicated in any existing ground test facility. To study this problem, in 2009 NASA initiated an effort to modify the Propulsion Systems Laboratory at the Glenn Research Center to enable research on ways to mitigate the effects of high-altitude icing and development of new engine certification procedures.

The FY 2011 budget request for Aeronautics includes $76.4 million for the **Aeronautics Test Program** (ATP)**,** which makes strategic investments to ensure availability of national ground facilities and flight assets to meet the testing needs of NASA and the Nation. The program also invests in the development of

new test instrumentation and test technologies. One such example is ATP's collaboration with the Aviation Safety Program to provide a new testing capability in the NASA-Glenn PSL facility to address the threat of high-altitude ice crystals to jet engine operability. The program recently demonstrated for the first time the ability to generate ice crystals at the very cold temperatures (-60 °F) encountered at commercial aircraft cruise altitudes. The PSL high-altitude ice crystal capability will become operational in FY 2011. The program also completed the development of a new Strategic Plan to provide the vision and leadership required to meet national goals; provide sustained support for workforce, capability improvements, and test technology development; and provide strategic planning, management, and coordination with NASA, government, and industry stakeholders. This plan will provide informed guidance as ATP develops a critical decision tool for building well-coordinated national testing capabilities in collaboration with the Department of Defense through the National Partnership for Aeronautical Testing (NPAT).

Partnerships with industry, academia, and other Federal agencies are critical to the success and relevance of NASA research. Through close collaboration, NASA ensures that it works on the right challenges and improving the transition of research results to users. NASA is using NASA/FAA Research Transition Teams (RTTs) to conduct joint research and field-trials to speed acceptance of new air traffic management procedures. The Agency is also coordinating management and operation of the Federal government's large aeronautics ground test infrastructure through the NPAT. Through NASA Research Announcements (NRAs), NASA solicits new and innovative ideas from industry and academia while providing support for Science, Technology, Engineering, and Math departments. The Agency also funds undergraduate and graduate scholarships, Innovation in Aeronautics Instruction grants to improve teaching programs at the university level, and sponsor student design competitions at undergraduate and graduate levels for both U.S. and international entrants. By directly connecting students with NASA researchers and our industrial partners we become a stronger research organization while inspiring students to choose a career in the aerospace industry.

Exploration

The FY 2011 budget request for Exploration is $4,263.4 million, an increase of $483.6 million above the FY 2010 enacted level. Included in this budget request is funding for three new, robust programs that will expand the capabilities of future space explorers far beyond those we have today. NASA will embark on these transformative initiatives by partnering with the best in industry, academia and other government agencies, as well as with our international partners. These partners have been integral to much of NASA's previous success and are vital to our bold new vision.

NASA will encourage active public participation in our new exploration missions via a new participatory exploration initiative. Additionally, the FY 2011 budget request builds upon NASA's commercial cargo efforts by providing significant funding for the development of commercial human spaceflight vehicles, freeing NASA to focus on the forward-leaning work we need to accomplish for beyond-LEO missions. The FY 2011 budget request is a 40 percent increase over last year's investment in the Human Research Program, to help prepare for future human spaceflight exploration beyond low-Earth orbit. Lastly, the Exploration FY 2011 budget request includes funding for the Constellation Program close-out activities spread across FY 2011 and FY 2012.

In the near term, NASA is continuing Constellation work to ensure an orderly closeout of the program in FY 2011 and to capture of all of the knowledge learned through its key efforts. The Constellation Program is focusing on completing its Preliminary Design Review (PDR), which will conclude this year. NASA believes that completing the Constellation PDR will support not only the close-out process for

Constellation, but also will ensure that historical data from Constellation work is documented, preserved and made accessible to future designers of other next-generation U.S. human spaceflight systems.

The Exploration FY 2011 budget request includes three new robust research and development programs that will enable a renewed and reinvigorated effort for future crewed missions beyond low-Earth orbit:

- **Technology Development and Demonstration Program**: $652.4 million is requested in FY 2011, and a total of $7,800.0 million is included in the five year budget plan, to invent and demonstrate large-scale technologies and capabilities that are critical to future space exploration, including cryo-fluid management and transfer technologies; rendezvous and docking technologies; and closed-loop life support systems. These technologies are essential to making future exploration missions more capable, flexible, and affordable.

- **Heavy-Lift and Propulsion Research and Development Program:** $559.0 million is requested in FY 2011, and a total of $3,100.0 million is included in the five-year budget plan, for an aggressive, new heavy-lift and propulsion R&D program that will focus on development of new engines, propellants, materials and combustion processes that would increase our heavy-lift and other space propulsion capabilities and significantly lower operations costs – with the clear goal of taking us farther and faster into space consistent with safety and mission success.

- **Robotic Exploration Precursor Program**: $125.0 million is requested in FY 2011, and $3,000.0 million is included in the five-year budget plan, for robotic missions that will pave the way for later human exploration of the Moon, Mars and nearby asteroids. Like the highly successful Lunar Reconnaissance Orbiter and Lunar Crater Observation and Sensing Satellite missions that captured our attention last fall, future exploration precursor missions will scout locations and demonstrate technologies to locate the most interesting places to explore with humans and validate potential approaches to get them there safely and sustainably.

Cross-agency teams for each of these three areas are working to develop plans that delineate key areas for research and development, specify milestones for progress and set launch dates for relevant missions. They will report to the Administrator over the coming months, and the results of their efforts will be shared with the Congress when they are complete.

The Exploration FY 2011 budget request for **Commercial Spaceflight** is $812.0 million, which includes $500.0 million to spur the development of U.S. commercial human spaceflight vehicles, and a total of $6 billion in the five-year budget plan**.** This investment funds NASA to contract with industry to provide astronaut transportation to the International Space Station as soon as possible, reducing the risk of relying solely on foreign crew transports, and frees up NASA resources to focus on the difficult challenges in technology development, scientific discovery, and exploration. We also believe it will help to make space travel more accessible and more affordable. An enhanced U.S. commercial space industry will create new high-tech jobs, leverage private sector capabilities and energy in this area, and spawn other businesses and commercial opportunities, which will spur growth in our Nation's economy. And, a new generation of Americans will be inspired by these commercial ventures and the opportunities they will provide for additional visits to space. NASA plans to allocate this FY 2011 funding via competitive solicitations that support a range of activities such as human-rating existing launch vehicles and developing new crew spacecraft that can ride on multiple launch vehicles. NASA will ensure that all commercial systems meet stringent human-rating and safety requirements before we allow any NASA crew member (including NASA contractors and NASA-sponsored International partners) to travel aboard a commercial vehicle on a NASA mission. Safety is, and always will be, NASA's first core value.

In addition to the $500 million identified for crew transportation development efforts, the budget also includes $312.0 million in FY 2011 for incentivizing NASA's current commercial cargo program. These funds--by adding or accelerating the achievement of already-planned milestones, and adding capabilities or tests--aim to expedite the pace of development of cargo flights to the ISS and improve program robustness**.**

Today, NASA is using $50.0 million from the American Recovery and Reinvestment Act of 2009 to help drive the beginnings of a commercial crew transportation industry. Through an open competition, in early February, NASA awarded Space Act Agreements to five companies who proposed ideas and concepts intended to make commercial crew services a reality. While there are many vibrant companies out there that we hope to partner with in the future, these five companies, along with our two currently funded Commercial Orbital Transportation Services partners (Space Exploration Technologies and Orbital Sciences Corporation) are at the forefront of a grand new era in space exploration.

The Exploration FY 2011 budget request includes $215.0 million for the **Human Research Program**, an increase of more than 40 percent over the FY 2010 enacted level, and an investment of $1,075 million over the five-year budget plan. The Human Research Program is a critical element of the NASA human spaceflight program in that it develops and validates technologies that serve to reduce medical risks associated for crew members.

The Exploration FY 2011 budget request includes $1,900.0 million for **Constellation Closeout** requirements, and a total of $2,500.0 million over the FY 2011-2012 timeframe. These funds will be used for related facility and close-out costs, potentially including increased costs for Shuttle transition and retirement due to Constellation cancellation. The Agency has established senior planning teams to outline options for Constellation close out expeditiously and thoughtfully and to assess workforce, procurement and other issues, which will report to the Administrator over the coming months, to ensure that people and facilities are best utilized to meet the needs of NASA's new missions. NASA will work closely with the Congress as these activities progress.

NASA recognizes that this change will personally affect thousands of NASA civil servants and contractors who have worked countless hours, often under difficult circumstances, to make the Constellation Program successful. I commend the investment that these dedicated Americans have made and will continue to make in our Nation's human spaceflight program. Civil servants who support Constellation should feel secure that NASA has exciting and meaningful work for them to accomplish after Constellation, and our contractor colleagues should know that NASA is working expeditiously to identify new opportunities for them to partner with the Agency on the new Exploration portfolio.

Space Technology

Through the new Space Technology Program, led by the recently established Office of the Chief Technologist, NASA will increase its support for research in advanced space systems concepts and game-changing technologies, enabling new approaches to our current mission set and allowing the pursuit of entirely new missions. Using a wide array of management, funding, and partnership mechanisms, this program will engage the brightest minds in private industry, across the NASA Centers, and throughout academia. This new program builds upon the success of NASA's Innovative Partnerships Program and directly responds to input from multiple NRC reports, as well as the Augustine Committee. The Space Technology program will meet NASA's needs for new technologies to support future NASA missions in science and exploration, as well as the needs of other government agencies and the Nation's space industry in a manner similar to the way NACA aided the early aeronautics industry. Many positive outcomes are likely from a long-term NASA advanced space systems concepts and technology

development program, including a more vital and productive space future than our country has today, a means to focus NASA intellectual capital on significant national challenges and needs, a spark to renew the nation's technology-based economy, an international symbol of our country's scientific and technological leadership, and a motivation for many of the country's best young minds to enter into educational programs and careers in engineering and science.

The FY 2011 budget request for Space Technology is $572.2 million, and $4,925.9 million is included in the five-year budget plan. With this initiative, NASA will expand its Technology and Innovation portfolio to include: open competitions to stimulate highly innovative, early-stage space system concepts and ideas; development of technologies that can provide game-changing innovations to address NASA and national needs; and development and infusion of cross-cutting capabilities into missions that address needs from multiple NASA Mission Directorates, other government agencies, and commercial activities in space, while fostering and stimulating a research and development culture at NASA Centers. Beginning in FY 2011, activities associated with the Innovative Partnerships Program are transferred to Space Technology.

The need for advanced capabilities is increasing as NASA envisions missions of increasing complexity to explore and understand the Earth, our solar system, and the universe. Technology and innovation are critical to successfully accomplishing these missions in an affordable manner. The Space Technology program will enhance NASA's efforts to nurture new technologies and novel ideas that can revolutionize our aerospace industrial base, as well as to address national and global challenges and enable whole new capabilities in science and exploration that will be of benefit to the Nation. Key focus areas include communications, sensors, robotics, materials, and propulsion. The Space Technology program will use open competitions such as NASA Research Announcements and Announcements of Opportunity, targeted competitions such as those for small business (SBIR), universities (STTR), and engage early career scientists and engineers. NASA will also continue to use challenges and prizes to stimulate innovative new approaches to technology development and will encourage partnerships with both established and emerging commercial space industries. Through the three major elements of this program--Early-Stage Innovation, Game-Changing Innovation, and Crosscutting Capabilities--a broad suite of management, funding and partnership mechanisms are employed to stimulate innovation across NASA, industry and academia.

The Early-Stage Innovation program element sponsors a wide range of advanced space system concept and initial technology development efforts across academia, industry and the NASA Centers. This program element includes: (a) the Space Technology Research Grant program (analogous to the Fundamental Aeronautics program within NASA's Aeronautics Research Mission Directorate) that focuses on foundational research in advanced space systems and space technology, (b) re-establishment of a NIAC-like Program to engage innovators within and external to the Agency in accordance with the recommendations of the NRC's *Fostering Visions of the Future* report, (c) enhancement of the Innovative Partnership Programs Seed Fund into a Center Innovations Fund to stimulate aerospace creativity and innovation at the NASA field Centers, (d) NASA's SBIR/STTR program to engage small businesses, and (e) the Centennial Challenges Prize Program to address key technology needs with new sources of innovation outside the traditional aerospace community. Competitive selection is a major tenet of all the activities within this low technology readiness level (TRL) program element.

The Game Changing Innovation program element focuses on maturing advanced technologies that may lead to entirely new approaches for the Agency's future space missions and solutions to significant national needs. Responsive to the NRC report, *America's Future in Space: Aligning the Civil Space Program with National Needs*, this program element demonstrates the feasibility of early-stage ideas that have the potential to revolutionize future space missions. Fixed-duration awards are made to PI-led teams comprised of government, academia and industry partners. These awards are evaluated annually for

progress against baseline milestones with the objective of maturing technologies through ground-based testing and laboratory experimentation. NASA intends to draw from DARPA's experience to create and implement collaborative game-changing space technology initiatives. New technologies considered may include advanced lightweight structures and materials, advanced propulsion, power generation, energy storage and high bandwidth communications. With a focus on such potentially revolutionary technologies, success is not expected with each investment; however, on the whole, and over time, dramatic advances in space technology enabling entirely new NASA missions and potential solutions to a wide variety of our society's grand technological challenges are anticipated.

A Crosscutting Capabilities program element matures a small number of technologies that are of benefit to multiple customers to flight readiness status. Technical risk, technology maturity, mission risk, customer interest, and proposed cost are discriminators planned for use in the selection process. For infusion purposes, proposing teams are required to have a sponsor willing to cost share a minimum of 25 percent of the planned development effort. With objectives analogous to the former New Millennium program, NASA will pursue flight demonstrations not only as standalone missions, but also as missions of opportunity on planned NASA missions as well as international and commercial space platforms. The Commercial Reuseable Suborbital Research Program (which provides suborbital flight opportunities for technology demonstrations, scientific research and education), the Facilitated Access to the Space environment for Technology (FAST) project (which focuses on testing technologies on parabolic aircraft flights that can simulate microgravity and reduced gravity environments) and the Edison Small Satellite Demonstration Missions project (which develops and operates small satellite missions in partnership with academia). are also included in this program element.

NASA has had past success in the development of game-changing technologies and the transfer of its products and intellectual capital to industry. As an example, consider the Mars Pathfinder mission of the early 1990s. In addition to accomplishing its science and technology objectives, Mars Pathfinder established surface mobility and ground truth as important exploration principles, created a groundswell of interest and a foundational experience for a new generation of Mars scientists and engineers, re-engaged the public with Mars as a destination worthy of exploration, led to the creation of NASA's Mars program and establishment of a Mars program budget line, and led to a wide spectrum of small missions to Mars, the asteroids, comets and other bodies in our solar system. For NASA's robotic exploration program, Mars Pathfinder was clearly a game-changer. In a more recent example, consider NASA's recent improvements to thermal protection system (TPS) materials through an Advanced Capabilities development project. Over three years, a NASA-industry team raised the TRL of 8 different TPS materials from 5 different commercial vendors, eventually selecting the best as the system for the Orion heat shield. In addition to providing a heat shield material and design for Orion on time and on budget, this Advanced Capabilities development project re-invigorated a niche space industry that was in danger of collapse, re-established a NASA competency able to respond to future TPS needs. For example, the team identified a potentially catastrophic problem with the planned MSL heat shield and remedied the problem by providing a viable alternate heat shield material and design within stringent schedule constraints. The mature heat shield material and designs have been successfully transferred to the commercial space industry, including the TPS solution for the SpaceX Dragon capsule. Beginning in FY 2011, the new NASA Space Technology program aims to strengthen and broaden these successful innovation examples across a wide range of NASA enterprises and significant national needs.

Space Operations

The FY 2011 budget request includes $4,887.8 million for Space Operations, funding the Space Shuttle program, the International Space Station Program, and the Space and Flight Support program.

The FY 2011 budget request for the **Space Shuttle** program is $989.1 million. In 2009, the Space Shuttle flew five times, delivering to the ISS its final set of solar arrays and the equipment needed to support a six-person permanent crew; servicing the Hubble Space Telescope; completing the assembly of the three-module Japanese Kibo science laboratory; outfitting the Station with two external payload and logistics carriers, the Materials Science Research Rack-1, the Fluid Integrated Rack, the Minus Eighty-Degree Laboratory Freezer, a treadmill, and air revitalization equipment; and, delivering key supplies.

In 2010, the Shuttle is slated to fly out its remaining four missions, including the recently completed STS-130 mission. In April, Shuttle Discovery will carry up critical supplies for the ISS using a Multi-Purpose Logistics Module (MPLM) and the Lightweight Multi-Purpose Experiment Support Structure Carrier (LMC). Atlantis will launch in May with the Russian Mini-Research Module-1, as well as the Integrated Cargo Carrier - Vertical Light Deployment (ICC-VLD). This summer, Endeavour will carry the Alpha Magnetic Spectrometer (AMS) and attach it to the Station's truss structure. The AMS is a particle physics experiment, which will use the unique environment of space to advance knowledge of the universe and contribute to understanding the universe's origin. AMS is presently undergoing critical thermal and electrical testing at the European test facilities in the Netherlands. If these tests are successful, AMS will ship to KSC in May for the July launch. The final Shuttle mission, STS-133, is targeted for September of this year. Discovery will carry supplies to ISS, as well as an MPLM that will be installed on ISS as a permanent module, expanding the Station's storage volume. This flight will mark the completion of ISS assembly.

For almost 30 years, the Space Shuttle has carried U.S. and international astronauts into orbit; played a key role in the construction, outfitting, and resupply of the ISS; serviced the Hubble Space Telescope five times; served as an Earth-orbiting laboratory through the Spacelab and SpaceHab missions; and deployed a diverse array of payloads, including science probes and research experiments (such as the Magellan mission to Venus and Earth-orbiting tether experiments), communications satellites; and even student projects. NASA recognizes the role the Space Shuttle vehicles and personnel have played in the history of space activity, and looks forward to transitioning key workforce, technology, facilities, and operational experience to a new generation of human spaceflight exploration activities.

FY 2011 will be the first full year of major Space Shuttle Program (SSP) transition and retirement (T&R) activities. T&R is focused on the retirement of the SSP and the efficient transition of assets to other uses once they are no longer needed for safe mission execution. These activities include identifying, processing, and safing hazardous materials, and the transfer or disposal of SSP assets, including the preparation of Orbiters and other flight hardware for public display. T&R also covers severance and retention costs associated with managing the drawdown of the SSP workforce.

A key element of America's future in space is the **International Space Station**. The FY 2011 budget request for the International Space Station Program is $2,779.9 million. As of May 2009, the ISS has been able to support a six-person permanent crew, and during the STS-127 mission last July, the Station hosted 13 astronauts representing the five space agencies in the ISS partnership, including those of the United States, Russia, Japan, Europe and Canada. The three major science labs aboard ISS were completed in 2009 with the delivery of the Exposed Facility of the Japanese Kibo module. In addition, the first flight of Japan's H-II Transfer Vehicle (HTV) was successfully carried out last fall, adding a new cargo-carrying spacecraft to the fleet.

This year will mark the completion of assembly of the ISS – the largest crewed spacecraft ever assembled, measuring 243 by 356 feet, with a habitable volume of over 30,000 cubic feet and a mass of 846,000 pounds, and powered by arrays which generate over 700,000 kilowatt-hours per year. The ISS represents a unique research capability aboard which the United States and its partner nations can conduct a wide variety of research in biology, chemistry, physics and engineering fields which will help us better

understand how to keep astronauts healthy and productive on long-duration space missions. Funding for ISS research is also reflected in the Exploration budget request and in the Space Technology budget request.

The FY 2011 budget request includes a dramatic increase in the Nation's investment in the research and capabilities of the ISS. With this investment, NASA will be able to fully utilize the ISS and increase those capabilities through upgrades to both ground support and onboard systems. Importantly, this Budget extends operations of the ISS, likely to 2020 or beyond. This budget makes a strong commitment to continued and expanded operation of the ISS. The United States as leader in space made this first step and will now work with the other ISS international partners to continue International operation of the ISS. ISS can inspire and provide a unique research platform for people worldwide.

ISS research is anticipated to have terrestrial applications in areas such as biotechnology, bioengineering, medicine and therapeutic treatment. The FY 2011 budget request for ISS reflects increased funding to support the ISS as a National Laboratory in which this latter type of research can be conducted. NASA has two MOUs with other U.S. government agencies, and five agreements with non-government organizations to conduct research aboard the ISS. NASA intends to continue to expand the community of National Laboratory users of the ISS. This budget request supports both an increase in research and funding for cargo transportation services to deliver experiments to the Station.

ISS can also play a key role in the demonstrations and engineering research associated with exploration. Propellant storage and transfer, life support systems, and inflatable technology can all benefit by using the unique research capabilities of ISS.

In addition to supporting a variety of research and development efforts, the ISS will serve as an incubator for the growth of the low-Earth orbit space economy. NASA is counting on its Commercial Resupply Services (CRS) suppliers to carry cargo to maintain the Station. The first CRS cargo flights will begin as early as 2011. It is hoped that these capabilities, initially developed to serve Station, may find other customers as well, and encourage the development of further space capabilities and applications. The suppliers 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.

As a tool for expanding knowledge of the world around us; advancing technology; serving as an impetus for the development of the commercial space sector; demonstrating the feasibility of a complex, long-term, international effort; and, perhaps most importantly, inspiring the next generation to pursue careers in science, technology, engineering, and mathematics, the ISS is without equal.

The FY 2011 budget request for **Space and Flight Support** (SFS) is $1,119.0 million. The budget request provided for critical infrastructure indispensable to the Nation's access and use of space, including Space Communications and Navigation (SCaN), the Launch Services Program (LSP), Rocket Propulsion Testing (RPT), and Human Space Flight Operations (HSFO). The SFS budget also includes a new and significant investment in the 21st Century Space Launch Complex, intended to increase operational efficiency and reduce launch costs by modernizing the Florida launch capabilities for a variety of NASA missions, which will also benefit non-NASA users.

In FY 2011, the SCaN Program will begin efforts to improve the robustness of the Deep Space Network (DSN) by initializing the replacement of the aging 70m antenna capability with the procurement of a 34m antenna. The NASA DSN is an international network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe. The DSN also supports selected Earth-orbiting missions. In the third quarter, a System

Requirements Review (SRR) of the Space Network Ground Segment Sustainment (SGSS) Project will be conducted, and the Program will have begun integration and testing of the Tracking and Data Relay Satellites (TDRS) K&L. In the area of technology, the Communication Navigation and Networking Reconfigurable Testbed (CoNNeCT) will be installed on ISS. This test bed will become NASA's orbiting SCaN laboratory on the ISS and will validate new flexible technology to enable greater spacecraft productivity. NASA will also have its first optical communication system ready for integration into the Lunar Atmosphere and Dust Environment Explorer (LADEE) spacecraft. In addition, the Disruption Tolerant Networking (DTN) protocols will complete their development at the end of FY 2011 and should be ready for operations throughout the solar system. The SCaN operational networks will continue to provide an unprecedented level of communications and tracking services to over 75 spacecraft and launch vehicles during FY 2011.

The LSP has six planned NASA launches in FY 2011 including Glory, Aquarius, Juno, Nuclear Spectroscopic Telescope Array (NuSTAR), NPOESS Preparatory Project (NPP) and the Gravity Recovery and Interior Laboratory (GRAIL) mission. In addition to processing, mission analysis, spacecraft integration and launch services, LSP will continue to provide support for the development and certification of emerging launch services.

The RPT Program will continue to provide test facility management, and provide maintenance, sustaining engineering, operations, and facility modernization projects necessary to keep the test-related facilities in the appropriate state of operational readiness. These facilities will support many of the tests planned under ESMD's propulsion research program.

HSFO includes Crew Health and Safety (CHS) and Space Flight Crew Operations (SFCO). SFCO will continue to provide trained crew for the manifested Space Shuttle requirements, four ISS long-duration crew rotation missions. CHS will identify and deliver necessary core medical capabilities for astronauts. In addition, CHS will gather astronaut medical data critical for determining medical risk as a result of space flight and how best to mitigate that risk.

The 21st Century Launch Complex initiative will primarily benefit NASA's current and future operations at the Kennedy Space Center (KSC), but will also help to improve KSC launch operations for future and current non-NASA users of the range, with the goal of transforming KSC into a modern facility. This new initiative focuses on upgrades to the Florida launch range, expanding capabilities to support commercial launch providers, such as commercial cargo flights and future commercial crew flights in support of ISS, and expendable launch vehicles in support of the Science mission directorate payloads and robotic precursor missions. Additional areas under consideration include modernization activities to support safer and more efficient launch operations; enhancing payload processing capabilities through capacity increases, improvement, and modernization, in addition to potentially relocating the KSC perimeter where appropriate and feasible, to enable certain existing private sector facilities to lie outside the security perimeter, thus making it far more convenient to use those facilities; environmental remediation to reduce the impact on the surrounding areas; and supporting the modernization of the launch range capabilities. We will fully coordinate this activity with all users of the range.

Education

The FY 2011 budget request for Education is $145.8 million. This budget request furthers NASA's commitment to inspiring the next generation of explorers in the STEM disciplines. In FY 2011, NASA will continue to strongly support the Administration's STEM priorities and will continue to capitalize on the excitement of NASA's mission to stimulate innovative solutions, approaches, and tools that inspire student and educator interest and proficiency in STEM disciplines. This strategy will increase the

distribution and impact of NASA progressive opportunities for elementary and secondary teachers, university faculty, students of all ages, and the public.

In FY 2011, NASA will support the Administration's STEM education teaching and learning improvement efforts, including Race to the Top and Educate to Innovate, while continuing efforts to incorporate NASA content into the STEM education initiatives of other federal agencies. This summer, NASA will launch *Summer of Innovation*, an intensive STEM teaching and learning program targeted at the middle school level that includes follow-on activities during the school year. NASA content and products will be incorporated into evidence-based summer learning programs across participating states with the goal of improving student academic performance and motivating them to pursue further education and successful careers. The FY 2011 request includes funding for *Summer of Innovation* over a three-year period.

NASA will also continue to partner with academic institutions, professional education associations, industry, and other Government agencies to provide K-12 teachers and university faculty with the experiences that capitalize on the excitement of NASA discoveries to spark their student's interest and involvement. Examples of such experiences are the NASA student launch initiatives and other hands-on payload development and engineering opportunities. The FY 2011 budget request also places increased emphasis on Education and cyber-learning opportunities and expands teacher pre-service, professional development and training programs. Additionally, NASA seeks to prepare high school students for undergraduate STEM study through experiences that blend NASA research and engineering experiences with classroom study and mentoring. Another Agency education goal is to broaden community college participation in NASA research and STEM workforce development.

In FY 2011, the Agency aims to increase both the use of NASA resources and the availability of opportunities to a diverse audience of educators and students, including women, minorities, and persons with disabilities. An example is the Innovations in Global Climate Change Education project that will be implemented within the Minority University Research and Education Program. The project will seek innovative approaches to providing opportunities for students and teachers to conduct research using NASA data sets to inspire achievement and improve teaching and learning in the area of global climate change.

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. 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 two themes: Center Management and Operations and Agency Management and Operations. The FY 2011 budget request includes $3,310.2 million for Cross Agency Support.

NASA's FY 2011 budget request includes $2,269.9 million for **Center Management and Operations,** which 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.

NASA's FY 2011 budget request includes $1,040.3 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, and Strategic Capabilities Assets Program. Beginning in FY 2011, activities associated with the Innovative Partnerships Program are transferred to the Space Technology program. The FY 2011 budget request provides:

- $428.1 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.

- $201.6 million for **Safety and Mission Success** activities required to continue strengthening the workforce, training, and strengthening the fundamental and robust checks and balances 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.

- $177.8 million for **Agency Information Technology Services**, 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.

- $29.8 million 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.

Construction and Environmental Compliance and Restoration

NASA Construction and Environmental Compliance and Restoration provides for the design and execution of all facilities construction projects, including discrete and minor revitalization projects, demolition for closed facilities, and environmental compliance and restoration. The FY 2011 budget request includes $397.4 million for Construction and Environmental Restoration, made up of:

- $335.3 million for the **Construction of Facilities** (CoF) Program, which funds capital repairs and improvements to ensure that facilities critical to achieving NASA’s space and aeronautics program are safe, secure, environmentally sound, and operate efficiently. The Agency continues to place emphasis on achieving a sustainable and energy-efficient infrastructure by replacing old, inefficient,

deteriorated building with new, efficient, high performance buildings that will meet NASA's mission needs while reducing future operating costs.

- $62.1 million for **Environmental Compliance and Restoration** (ECR) Program, which supports the ongoing cleanup of current or former sites where NASA operations have contributed to environmental problems. The ECR Program prioritizes these efforts to ensure that human health and the environment are protected for future missions. This program also supports strategic investments in environmental methods and practices aimed at reducing NASA's environmental footprint and lowering the risks of future cleanups.

Conclusion

Americans and people worldwide have turned to NASA for inspiration throughout our history – our work gives people an opportunity to imagine what is barely possible, and we at NASA get to turn those dreams into real achievements for all humankind. This budget gives NASA a roadmap to even more historic achievements as it spurs innovation, employs Americans in fulfilling jobs, and engages people around the world as we enter an exciting new era in space. NASA looks forward to working with the Committee on implementation of the FY 2011 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.