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March 17, 2011

Statement of
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before the

Committee on Commerce Science, and Technology
United States Senate

Mr. Chairman and Members of the Committee, it is my privilege to appear before you today to discuss NASA's portion of the President's FY 2012 Federal Research and Development and Science budgets. Maintaining our status as the world's leader in innovation, education, science and technology is directly linked to our ability as a nation to push the frontiers of human understanding in innovative and transformational ways. NASA leads the Nation on a great journey of discovery, seeking new knowledge across domains that range from right here at home to distant galaxies and everywhere in between. In collaboration with the Nation's science community, NASA's space-based and suborbital observatories conduct scientific studies of the Earth, explore the nature and behavior of the Sun and other bodies in our solar system, and peer toward the edges of the universe, back toward the beginning of time. The International Space Station, with construction complete in 2011, will serve as a fully functional and permanently crewed research laboratory and technology test bed in orbit around Earth. Work on board the International Space Station will expand scientific research opportunities in the areas of biological and physical research as well as technology development in the microgravity environment.

From space, in space, and about space, NASA's science efforts are focused on pursuing questions that are rooted at the very core of the human spirit. These range from a practical curiosity about the environment in which we live, to a wondrous fascination about what lies beyond. What child has not peered at the stars, planets and comets in the night sky and wondered – "What is it like there? How many stars are out there? Is there life out there? Can we go there someday?" That wonder carries with us through adulthood and is a part of who we are. At the same time, who cannot look at the images of the Earth from space – a beautiful blue, green, and white globe, seemingly suspended against a dark and silent backdrop, carrying the whole of human civilization abuzz on its surface – and not wonder how it works and how it is changing? There is tremendous value to understanding how and why our planet is changing and what the future Earth will look like. There is economic value; there is humanitarian value; there is political value, and there is value for ensuring our security. NASA Science inspires and serves

humankind in ways that are truly unique and in ways that are critical for ensuring that we as a society not only survive, but thrive, in whatever future the human race carves out for itself.

Recognition of NASA's remarkable science contributions comes from many places. In the simplest sense, it can be seen in the incredulous eyes of people who see images of the famous Butterfly nebula or the Martian surface for the first time. It can also be evident in the appreciation of the farmer whose crop output is increased through the use of NASA data and information. However, one of the most notable validations of the value of NASA science comes from objective assessments by scientific journals. In its report of the top ten insights of the 2000-2010 decade, the journal *Science* identifies four achievements that are directly derived from NASA science investments. *Discover Magazine's* 100 Top Science Stories of 2010 include fifteen NASA stories. American Physical Society's counts three NASA science stories among its Top Ten Physics-related News Stories of 2010. And the list goes on.

As NASA's newly appointed Chief Scientist, it is my job, honor and privilege, to work in conjunction with the leaders of the Agency and the scientific community to ensure that the Nation's space program delivers the most valuable science for the taxpayer investment. Doing so requires that our goals remain focused, rich in content, and mindful of the resources available in our current, challenging fiscal environment. NASA's proposed FY 2012 budget request supports a diverse science and research and development (R&D) portfolio that reflects key priorities, while making some difficult choices that allow us to continue to invest in our Nation's future. This budget acknowledges that we must be good stewards of the tax payers' science and technology investments, while providing the Nation with the advancements necessary to maintain our global leadership and inspire our next generation of leaders in science, technology, engineering and math. The FY 2012 budget supports the key scientific priorities that are developed through a rigorous process of scientific community engagement by the National Academy of Sciences known as decadal surveys.

NASA's journey of scientific discovery also helps motivate, support, and prepare for human expansion into the solar system. Science missions provide critical insights into the radiation environment of deep space, the characteristics and compositions of planetary atmospheres, the terrain and geology of planetary surfaces, and the nature and origin of small bodies. They identify the hazards and resources present as humans explore space and the science questions and regions of interest that warrant detailed examination by human explorers.

The importance of NASA Science was recognized by Congress more than a half-century ago and codified in our founding document, the National Aeronautics and Space Act of 1958. The Act explicitly states:

> "The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:
>
> > (1) The expansion of human knowledge of the Earth and of phenomena in the atmosphere and space;" [section 102(d)]

Thus establishing science as a core element of NASA's mission. The return on investments in NASA science over the years have been tremendous, and the President's FY 2012 budget request provides for continued investments that will move the nation forward in important and inspiring scientific endeavors.

Earth Science

The view from space allows scientists to study planet Earth as a complex system with diverse interacting components: the oceans, atmosphere, land, ice, and life. NASA assets observe processes that are global in nature with local impacts, and that are local in nature with global impacts. By observing the interactions of these various components, we are able to develop a comprehensive picture of how the Earth works, how it is changing, why it is changing, and ultimately, what these changes mean for life on Earth. The knowledge we derive from this comprehensive picture, which is essential for ensuring our well-being as a society, can only be realized when the Earth is viewed in the context, scale, and perspective afforded by these space-based capabilities. From quantifying the impacts of melting ice on sea level, to understanding the inner workings of hurricanes and tropical storms, to assessing the health and amount of global vegetation, NASA Earth Science provides advances in understanding that positively benefit the lives of billions of people all over the world.

In addition to the scientific research and the new knowledge that NASA investments provide, NASA Earth Science also has real-time direct applicability to many national needs. Through our partnerships with other agencies (e.g., the National Oceanic and Atmospheric Administration (NOAA), the United States Geologic Survey (USGS), the Environmental Protection Agency (EPA)) that maintain forecasting and decision support systems, we ensure complementary, not duplicative activities. The result of these partnerships is improved national capabilities for climate predictions, weather, and natural hazards; the management of resources; and development of environmental policy. NASA's Earth Science is an essential part of the national and international efforts to understand the global environment and use Earth observations and scientific understanding in service to society.

There are too many examples of the direct societal benefits gained from NASA's Earth Science missions to list them all here today. However, I would like to highlight a few for your consideration. Once such example is the use of the Thermal Infrared Sensor (TIRS), currently flying on the Landsat 5 and 7 spacecraft and now in development for the Landsat Data Continuity Mission. TIRS plays an important role in the water management efforts in the western United States. In particular, TIRS measurements are used operationally by state agencies to monitor snowpack runoff and water consumption on a field-by-field basis in nine western states (Nevada, Idaho, Wyoming, Montana, Colorado, New Mexico, Nebraska, North Dakota and South Dakota). State water managers call TIRS's data the "gold standard" for the cost-effective administration of water transfer agreements, and an irreplaceable tool for western water managers. In 2012, NASA will begin to work with the Department of the Interior to develop successor Landsat satellites, through an operational program funded by USGS.

The Moderate Resolution Imaging Spectroradiameter, or MODIS instrument, on the Terra and Aqua spacecrafts provides data for the MODIS Rapid Response System developed to provide daily satellite images of the Earth's landmasses within a few hours of acquisition. This capability makes the system a valuable resource for organizations like the U.S. Forest Service and the international fire monitoring community, which use the images to track fires; the United States Department of Agriculture Foreign Agricultural Service, which monitors crops and growing conditions; and the United States Environmental Protection Agency and the United States Air Force Weather Agency, which track dust and ash in the atmosphere. As a final example, NASA-sponsored investigations have developed and demonstrated reliable and accurate detection of volcanic ash clouds using data from instruments on NASA Earth Science satellites, including the MODIS, MISR, OMI, and CALIOP instruments on the Terra, Aqua, Aura, and Cloudsat NASA research missions. The proven utility of these data led to their operational use by the NOAA National Weather Service to formulate Volcanic Ash Advisories. These products were used extensively during the Iceland volcano eruption in April 2010 and more recently, NASA satellite data were used to produce volcanic ash advisories for aviators across the Gulf of Mexico during the February 1 eruption of the Popocatepetl volcano in Mexico.

These practical benefits are not only realized here at home, but also abroad as is currently the case for the recent devastating earthquake in Japan. As with the previous earthquakes in Chile, Haiti, and elsewhere, NASA has been collecting and analyzing data from multispectral, multi-angle, and multiple resolution sensors to support damage assessment and response activities. We will continue the vital work to expand our abilities to observe our planet Earth and make those data available for decision makers and international partners.

NASA's FY 2012 budget request for Earth Science supports the development and launch of five foundational decadal missions guided by the priorities in the 2007 National Academy of Science Decadal report. We had certainly hoped to be examining and distributing new information from the Glory mission in 2012, but as is sometimes the case in the high-risk space business, the launch of Glory was unsuccessful. The FY 2012 request does, however, support exciting and high priority missions that include Aquarius, NPOESS Preparatory Project, Landsat Data Continuity Mission, and the Global Precipitation Measurement mission. In addition, the FY 2012 request supports the development and launch of the Orbiting Carbon Observatory-2, as well as the continued formulation and development of Soil Moisture Active and Passive (SMAP) and Ice Cloud and land Elevation Satellite-2 (ICESat-2), the first two Tier 1 Earth Science Decadal Survey missions, with targeted launch dates in November 2014 and January 2016, respectively.

Space Science

Robotic space probes allow us to extend humankind's presence into Earth's orbit and beyond. Through these missions we learn about our moon, the outer planets and their moons, asteroids and comets, icy bodies of the solar system, and we unravel some of the mysteries of our universe. NASA's FY 2012 budget request supports a robust space science mission portfolio including the Mars Science Laboratory (MSL), the Nuclear Spectroscopic Telescope Array (NuSTAR), the Radiation Belt Storm Probes (RBSP) and continued support for U.S. scientists through the research and analysis programs. MSL launches later this year and will arrive at Mars in August 2012. About the size of a subcompact car, MSL will assess whether Mars ever was, or is today, an environment able to support microbial life. The Nuclear Spectroscopic Telescope Array mission will launch in early 2012 and become the first focusing hard X-ray telescope to orbit Earth. NuStar will give us new insight into how black holes are distributed through the cosmos, how heavy elements were forged in the explosions of massive stars, and what powers the most extreme active galaxies. The FY 2012 budget provides stable footing for the James Webb Space Telescope (JWST) while the Agency develops a revised program plan and a reassessment of schedule and lifecycle cost. The new plan will be reflected in the 2013 President's Budget Request; however, the FY 2012 investment puts JWST well on its way to enabling us to view further into the universe and closer to its beginnings than ever before. Through NASA's research and analysis programs, scientists will continue to use the vast volumes of data from NASA spacecraft, sounding rockets, balloons, and payloads on the ISS to further fuel the Nation's research advancements.

On March 7, 2011, the National Academy of Sciences (NAS), National Research Council (NRC) announced the results of the long-awaited decadal survey for NASA's planetary missions. In its report, *Vision and Voyages for Planetary Science in the Decade 2013—2022*, the Academy outlined the scientific priorities for planetary missions for the next decade. The committee emphasized the importance of utilizing realistic cost estimates, and recognized both the challenges we face in the current fiscal environment and the importance of capitalizing on our international partnerships to help us accomplish larger, flagship missions. The committee's two highest priority large-class missions include the Mars Astrobiology Explorer-Cacher and a Jupiter Europa Orbiter. The report also strongly endorsed the importance and fundamental contributions to planetary exploration made by NASA's competitive Discovery (small missions) and New Frontiers (medium missions) programs. As with other decadal surveys, NASA is assessing the committee's recommendations and will use them to guide the strategic planning for upcoming missions. This report follows another decadal survey in Astrophysics released in 2010, *Astrophysics 2010: New Worlds, New Horizons in Astronomy and Astrophysics* that continues to shape our astrophysics investments. A similar report for heliophysics is under way and is expected to be completed in 2012.

Life and Physical Sciences Research

With the extension of International Space Station (ISS) operations to 2020 or beyond, we are able to expand the fundamental knowledge of biological and physical processes in the microgravity environment. NASA's FY 2012 budget provides for investments in this aspect of NASA research, taking advantage of the unique environment and capabilities of the ISS research facility. Fundamental space biology research will investigate the effects of gravity and the space environment on cellular, microbial, and molecular processes and comparative responses of whole organisms and their systems. This research will help scientists better understand the molecular and cellular basis for human disease and sub-optimal performance, with potential benefits both to astronaut health and the health of the general population. Under microgravity conditions, researchers gain important insights into gene differentiation and the structures of complex macromolecules, with potential applications in the design of new drugs and the development of vaccines. Physical sciences research will explore the fundamental laws of the universe and provide a foundation for the development of advanced exploration systems that will enable humans to explore space in a more sustainable and affordable way. In April, the National Research Council will deliver to NASA the first decadal survey on life and physical sciences that will provide us with the guidance to ensure we maximize the return on our science investments in ISS and in life sciences and microgravity research.

The Human Research Program (HRP) and its associated projects will continue to develop technologies, countermeasures, diagnostics, and design tools to keep crews safe and productive on long-duration space missions. Utilizing the Bioastronautics Roadmap, a risk reduction strategy developed in conjunction with the Institute of Medicine, the HRP identifies the top priority risks to crew health and carries out research targeted at developing countermeasures to reduce these risks. The ISS is critical to validating many of these countermeasures.

The ISS as a National Laboratory is a national resource to promote opportunities for advancing science and technology to other U.S. government agencies, university-based researchers and private firms. These other organizations will use the ISS to pursue basic and applied research in fields such as human health, energy, the environment and STEM education. NASA currently has Memoranda of Understanding with five federal agencies and nine Space Act Agreements (SAAs) with companies and universities for use of the ISS as a National Laboratory. These organizations include:

- The National Institutes of Health (NIH), which issued a 3-yr rolling Funding Opportunity Announcement for ISS-based investigations in March 2009 to include two-phase awards of up to $1.5M per grant over 5 years. Three first-round grants for the ground-based phase totaling an estimated $1.3M were awarded in August 2010;
- The National Science Foundation, which funded a study using ISS as a platform for deploying CubeSats to study the upper atmosphere; and
- AstroGenetix Inc., which continues to make progress on their vaccine development project.

In support of the National Laboratory effort, NASA recently released a Cooperative Agreement Notice (CAN) for an independent Non-Profit Organization to manage the multidisciplinary research carried out by NASA's National Laboratory partners. This organization will: 1) act as a single entry point for non-NASA users to interface efficiently with the ISS; 2) assist researchers in developing experiments, meeting safety and integration rules, and acting as an ombudsman on behalf of researchers; 3) perform outreach to researchers and disseminate the results of ISS research activities; and 4) provide easily accessed communication materials with details about laboratory facilities, available research hardware, resource constraints, and more. NASA plans to make an award for this organization in late spring. The NPO will oversee all research involving organizations other than NASA and transfer current NASA biological and physical research to the NPO in future years.

Linkages with Technology

Within NASA, technology and science work hand-in-hand, with technology enabling science and the science guiding technology. The Fiscal 2012 budget provides for continuation of our groundbreaking research into the next generation technologies. The investments are required to enable NASA's future Science missions as well as those in Aeronautics and Exploration. NASA invests in technology development in each of its Science areas. For Science, NASA's technology programs serve as an innovation engine, investing in the high payoff, high-risk ideas and technologies of tomorrow that industry cannot tackle today. This unique work also attracts bright minds into educational and career paths in STEM disciplines, and enhances the Nation's technological leadership position in the world.

Conclusion

NASA science contributes directly and substantially to current national priorities. As a leader in fundamental research, NASA works in and across the fields of Astrophysics, Planetary Science, Heliophysics, Earth Science, Life Sciences, Physical Sciences and technology development in ways that are unique to NASA's mission. The Science budget funds these missions as well over 3,000 competitively-selected research grants involving over 10,000 scientists, engineers, technologists, and their students across the Nation. The U.S science community's drive for innovation is unwavering and is ready to produce the new discoveries and technologies that feed a strong economy.

NASA science is unique - targeting not only matters of the human mind, but also matters of the human spirit and nourishing our need to explore the unknown. With a balanced and diverse portfolio, we diligently seek to understand the world in which we live, the Sun that fuels us, our celestial neighbors, and the universe beyond. These endeavors both inspire and serve human kind. They are timeless and priceless. And they will continue to enable the United States to lead the world toward a future that will no doubt exceed what we can only imagine today.