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Statement of
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before the

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Committee on Science, Space and Technology
United States House of Representatives

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to testify on NASA's technology transfer and commercialization efforts and how investments in cutting-edge research and development endeavors such as those seen through space exploration benefit the entire Nation. With the FY 2013 President's budget request for NASA, America is moving forward with an ambitious program of space exploration that builds on new technologies as well as proven capabilities as we expand humanity's reach into the solar system. While reaching for new heights in space, NASA is creating new jobs right here on Earth, especially for the next generation of American scientists and engineers, by supporting cutting–edge innovations in aeronautics and space technology research and development that will help fuel the Nation's economy for years to come.

On a personal note, I am honored to be at NASA serving as its Chief Technologist. As the NASA Administrator's top advisor on technology, I am responsible for guiding strategic Agency investments in technology; facilitating technology transfer, partnerships and commercialization activities across the Agency; advocating externally on behalf of NASA's R&D programs; demonstrating and communicating societal impacts of NASA technology investments; as well as, the executive management of the Space Technology Program.

The National Research Council (NRC) recently released its review of NASA's Space Technology Roadmaps, a comprehensive collection of technology strategies and pathways to advance the Nation's current capabilities in space. "Success in executing future NASA space missions will depend on advanced technology developments that should already be underway," wrote the NRC. "It has been years since NASA has had a vigorous, broad-based program in advanced space technology development, and NASA's technology base is largely depleted." The Space Technology Program has been engineered to refocus NASA on solving the toughest technological challenges so our Nation can pursue goals currently beyond our grasp.

As requested in your invitation to appear today, my testimony will address NASA technology transfer and commercialization efforts, which are often referred to as "spinoffs," and how NASA broadly shares its research and development to benefit commercial endeavors and the Nation. My testimony will also discuss a critically important part of this process—how the Office of the Chief Technologist coordinates and prioritizes R&D investment across NASA, and what NASA is doing to address the findings cited in the Inspector General audit of the Agency's technology transfer activities.

NASA Research and Technologies Drive the Growing Space Industry

Since its inception, NASA has been charged by its founding legislation The National Aeronautics and Space Act of 1958 to "provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." As we seek to achieve our national objectives in human space exploration, aeronautics, and scientific discovery, we create signposts in the form of data and research results that serve as pathfinders for subsequent advancements within the aerospace community. To give a sense of the magnitude of data available, NASA's Technical Reports Server (NTRS), which makes the Agency's technical literature and engineering results available to the public, holds over 500,000 aerospace-related citations, 200,000 full-text online documents, and 500,000 images and videos. Each year over 3.3 million people access NTRS. NTRS content continues to grow as new scientific and technical information is created or funded by NASA. The types of information found in the NTRS include conference papers, journal articles, meeting papers, patents, research reports, images, movies, and technical videos.

Commercial aerospace enterprise and researchers alike have access to and utilize data and analysis on topics such as: aerodynamics, propulsion, aircraft construction, materials, engineering, mathematical and computer sciences and so much more. By sharing NASA's findings and results, and making available NASA expertise to industry, the Agency has enabled airplane manufacturers to find the data they needed to build more fuel efficient aircraft. Satellite manufacturers have learned what materials endure in the harsh environment of space, thanks to reports from the Long Duration Exposure Facility (LDEF) and the Materials International Space Station Experiment (MISSE) test beds. In addition, NASA's workforce provides technical assistance. By providing companies with support from Agency experts, NASA can help solve technical challenges similar to those seen by the Agency. This hands-on support has helped companies like SpaceX quickly determine what type of heat shield was required to return cargo safely from space.

NASA Aeronautics Technology

NASA continues to lay the foundation for the future of flight by exploring new ways to manage air traffic, build more fuel-efficient and environmentally friendly airplanes, and ensure aviation's outstanding safety record. Through the research we conduct and sponsor with universities and industry, we help to develop the technology that enables continuous innovation in aviation.

NASA-developed technologies are in the DNA of many of the civil and military aircraft the U.S. industry has developed and marketed to date. American manufacturers have introduced highly competitive aircraft and engines in the last two years. With the introduction of these new products, our Nation's manufacturers appear to be well positioned in the large commercial transport market for some time to come. However, their success is not assured, and careful attention to aeronautics investment is required to maintain American leadership in this area.

NASA is investing in cutting edge research to accelerate implementation and enhance the capabilities of the Nation's Next Generation Air Transportation System (NextGen) in partnership with the FAA and other Joint Planning and Development Office partners. With our partners, we are investing in critical areas of research such as new air traffic management concepts for new fuel-efficient arrival procedures. And we are leading the country with a vision and revolutionary capabilities for the Nation's future air transportation system, researching concepts and technologies that may provide the foundation for future commercial products and services brought to the market.
We transfer the outcome of fundamental and systems-level aeronautics research to the aerospace community through dissemination of research results, concepts, and design methods. In some instances, companies may build on specific technologies and capabilities developed through NASA research,

investing their own research and development resources to take those last steps toward becoming a commercialized product. In other instances, NASA provides design methods and understanding used by companies in developing new products. By maturing new technologies and validating design methods, NASA research can help decrease the risk of incorporating new technologies and systems in aircraft, shortening the path through safety certification in the Federal Aviation Administration and speeding the transition of new technologies into the fleet.

Sparking Innovation on Earth

While not the Agency's primary objective, NASA provides America with unique capabilities simply because we take on extraordinarily difficult problems in technology and science. By taking humans to inhospitable places, we learn key skills, like keeping people healthy when the nearest hospital is days away. Meeting these challenges translates into benefits like the advanced ultrasound devices created in partnership with NASA, Henry Ford Hospital in Detroit, and the Epiphan company in Springfield, New Jersey. Using this portable ultrasound machine, a non-physician can, with minimal technical know-how, send medical imaging for consultation with experts. This device is now employed by emergency medical personnel around the country, as well as by coaches and sports teams. This example is just one of hundreds that show how solving technical problems in aerospace, we are also inventing technologies that make life better right here on Earth.

NASA's investments also stimulate the growth of the innovation economy. Knowledge provided by weather and navigational spacecraft, efficiency improvements in both ground and air transportation, super computers, solar- and wind-generated energy, the cameras found in many of today's cell phones, improved biomedical applications including advanced medical imaging and even more nutritious infant formula, as well as the protective gear that keeps our military, firefighters and police safe, have all benefitted from our nation's investments in aerospace technology.

We also see benefits of NASA innovation with companies like GreenField Solar, who developed PhotoVolt solar cells through cooperation with NASA's Glenn Research Center in Cleveland, Ohio. When paired with the StarGen solar concentrator, which tracks and captures the sun's rays throughout the day, this system can concentrate sunlight up to 900 times its normal intensity to dramatically boost the efficiency of solar panels. GreenField solar is now generating grid-scale solar power at a lower cost per kilowatt-hour than most existing photovoltaic systems. U.S. job opportunities will increase as GreenField ramps up its commercialization efforts. This is a single example, but one of nearly 2,000 NASA has collected in its annual *Spinoff* publication.

While these stories provide a collective and qualitative answer to the question of the benefits of NASA technology here on Earth, the question still remains as to the true return on investment of NASA's activities. Toward that end, NASA has begun new methods for capturing the impact of secondary use of NASA-funded discoveries. A multiplier showing NASA's return on investment is not the goal. Rather, NASA is working to supplement the traditional reporting in *Spinoff* with quantitative data, and through analysis of this data, providing a better understanding and an ongoing measurable record of the societal benefits resulting from the Agency's investment in innovation. By surveying firms represented by those stories in *Spinoff*, NASA has collected quantitative data retrospectively on the numbers of jobs created; revenue generated; productivity and efficiency improvements; lives saved; and lives improved as a result of NASA technology transfer.

NASA will collect and standardize reporting of these quantitative benefits each year, as the *Spinoff* stories are collected and developed. While only a subset of all the benefits generated by the Nation's investment in space research and technology, this new qualitative framework provides a sustainable and consistent

source of data from the top technology transfer successes published in *Spinoff* each year, with the data coming directly from the firms that are commercializing NASA technologies.

To date, the returns have proven impressive. NASA can now say with certainty that technology transfer has helped to create thousands of jobs, generated billions of dollars in revenue, and saved hundreds of thousands of lives. For example, we consider the worldwide search and rescue system founded thanks to NASA innovation. Enabled in part by satellite ground stations developed and constructed by a NASA partner, the true value of this spinoff is incalculable—more than 30,000 lives saved, on average more than 6 a day, from the highly publicized 2010 rescue of teen sailor Abby Sunderland to fishermen, hikers, and adventurers around the world. While this type of data represents an important aspect of NASA's efforts to document its spinoff successes, it still tells only a part of the exciting, complex, and unique stories of the NASA and industry innovators who create these technologies, the partnerships that help deliver them to the public, and the individuals and communities who benefit.

Technology Transfer

NASA's directional shift toward increased technology development has allowed the agency to energize the inventors, engineers and technologists, enlisting their help in bridging the gap from today's NASA to that of tomorrow. New technologies will bring improvements in how we explore, navigate and understand our universe. They will also represent new opportunities for industry and small businesses alike to gain from government funded research and development. Through the work of the NASA Innovative Partnership Office(IPO), the Office of the Chief Technologist (OCT) develops partnerships and manages the transfer of NASA-developed technology to industry, connecting NASA's research and development to those who can apply it to commercial use.

IPO works with all NASA Mission Directorates and Centers to ensure Agency-developed technologies, processes, discoveries, and knowledge are available to the private sector. Technology transfer at NASA is conducted through various means including public-private partnerships with local, state and regional organizations; collaborations and cooperative activities with commercial companies, other Government agencies and academic and research institutions for the purpose of developing technologies to both enable NASA to meet its mission needs and to contribute to the nation's commercial competitiveness; and traditional intellectual property management, such as licensing of patented technologies.

This spring, the NASA Inspector General concluded an audit of NASA's technology transfer activities and noted that:

- NASA personnel lack awareness of the agency's technology transfer policy requirements;
- technological assets are not consistently identified or fully understood;
- innovators lack awareness of new technology reporting process; and,
- new technology reports are inaccessible.

NASA agreed with the findings and is making improvements to its program and process.

The Agency is rewriting its technology transfer policies to better match current best practices as well as address commercialization planning. The new policy will provide a streamlined, broad, flexible approach to core technology transfer activities, with an emphasis on coordination of technology transfer offices with programs and projects. This increased coordination will assist NASA in best understanding the value of identified technological assets. Revised policies will go into effect in 2013, at which time NASA will pursue activities to increase internal awareness of these policies.

To build awareness of the new technology reporting requirements, NASA has launched a series of initiatives to increase new invention capture, including the development of an online training module, a redesign of the online system for invention disclosure, and an active outreach campaign.

Building awareness of the new technology reporting and technology transfer processes will improve the understanding of what happens when a new technology report is submitted. Additionally, the engagement with programs and projects at the early stages of commercialization planning will further help innovators to understand what happens when a new technology report is submitted.

NASA is also considering development of a system, similar to a package delivery tracking system, where innovators would log on to the online submission system to see where in the process the disclosure is.

NASA embraces the challenges of addressing the Inspector General's concerns, as the Agency recognizes the importance of this program, not only to NASA, but also the Nation.

Not only is technology transfer important to NASA, but the President charged all Federal agencies with accelerating technology transfer activities[1] and, thereby, the benefits of Federally-funded research and development investments. NASA is strategically positioned to answer that call, building upon a legacy of leadership in technology and transfer of space and aeronautics research for public benefit. In response to that directive, NASA is in the process of developing a five-year plan to improve its technology transfer program activities. Key objectives in the draft plan include the following:

- fill the technology-transfer pipeline through a renewed, Agency-wide emphasis in technology research and development;
- revise the Agency's policies on commercialization to ensure alignment with NASA's current focus on technology development and best practices in technology transfer;
- build partnerships for technology development, transfer, and mutual benefit;
- tie the technology-transfer process into all stages of technology development, ensuring that formal technology transfer is considered even at the earliest stages, when programs and activities are being formulated and acquisitions planned;
- increase the number of new technologies reported by NASA civil servants and contractors;
- improve licensing processes and outcomes; and,
- consider other tools and authorities for accelerating licensing of technologies.

Each of these objectives is supported by a series of identified activities and metrics, and the NASA field center technology transfer offices are working to develop an implementation plan to move out on these activities in FY 2013.

Additionally, NASA is in the process of supplementing the core Agency technology transfer capabilities by restoring resources for technology assessments, bridge funding, market analysis, and marketing of technologies.

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1 Presidential Memorandum -- Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses http://www.whitehouse.gov/the-press-office/2011/10/28/presidential-memorandum-accelerating-technology-transfer-and-commerciali

NASA has already implemented improvements in communication of its technology transfer efforts through the launch of its new Technology Transfer Portal: http://technology.nasa.gov. The portal is an Internet-based, one-stop shop for the Agency's intellectual property assets. The site features a searchable, categorized database of NASA's patents, a module for reaching out to a NASA technology transfer specialist, and articles about past successful commercialization of NASA technology. Historical and real-time data for NASA's technology transfer program also are available at any time. The public can access interactive graphs showing how many inventions NASA is reporting, how many of those are patented, and how any are licensed to industry for commercial application.

Other initiatives have been identified and are being implemented to help NASA fulfill its technology transfer goal and objectives such as, an automated licensing pilot and a student business plan competition built around NASA intellectual property.

To further demonstrate NASA's commitment to technology transfer, NASA has added technology transfer to the top-level, Agency-wide performance goals reported annually to the Office of Management and Budget (OMB). For FY 2012 to 2013, one of NASA's five Agency Priority Goals (APGs) is a set of key technology transfer metrics. This performance goal emphasizes that NASA is committed to the transfer of NASA technologies to industry, academia and other Government agencies to improve the U.S. economy and the quality of life for all Americans.

Investments in Space Technology Spur Innovation

Each NASA mission takes years of planning and development to ensure its success, and every NASA mission has been made possible by pushing the technology envelope. If NASA and this Nation are to reach the goals set for us by this Congress, we must drive to innovate. The Office of the Chief Technologist (OCT) coordinates the Agency's technology programs, one of which is the Space Technology Program. This program's mission is advancing technologies and concepts that address NASA's needs and contribute to other aerospace and national needs. It is no accident that the same office is the home of both technology development and transfer efforts; the two are naturally synergistic. OCT identifies development needs across the Agency, prioritizes those needs according to stakeholder input, and reduces duplication to ensure that the Agency's resources are used wisely. By coordinating technology programs across NASA, OCT facilitates infusion of available and new technology into systems that ultimately advance specific human-exploration missions, science missions, and aeronautics capabilities. And with the help of the incredible new ideas that are emerging from the Space Technology Program, OCT is helping to ensure a robust technology transfer enterprise for the Agency.

In managing the Space Technology Program, OCT employs a portfolio approach, investing in both crosscutting and human exploration specific technology needs for the Agency. The broadly relevant technologies being pursued within the Program span a range of discipline areas and technology readiness levels (TRL) from concept study to flight demonstration, including technology demonstrations conducted on the International Space Station.

Building partnerships for technology development, transfer, and mutual benefit is a key objective of the Space Technology Program. NASA's partnership programs are robust, maximizing our resources and increasing benefits to the Agency and the Nation as a whole. NASA participates in national technology-development initiatives such as the National Nanotechnology Initiative, the Advanced Manufacturing Partnership and the National Robotics Initiative to increase opportunities for collaborative technology development. In the latter, four agencies (the National Science Foundation, the National Institutes of Health, NASA, and the Department of Agriculture) have issued a joint solicitation that will provide up to $70 million in research funding for next-generation robotics. This partnership focuses on developing

robots that work with or beside people to extend or augment human capabilities, taking advantage of the different strengths of humans and robots. In addition to investing in the core technology needed for next-generation robotics, the initiative will support applications such as robots that can: increase the productivity of workers in the manufacturing sector; assist astronauts in complex, hazardous, and challenging missions; help scientists accelerate the discovery of new, life-saving drugs; and improve food safety by rapidly sensing microbial contamination.

Space Technology development takes place using NASA centers, academia and industry, and through collaboration with other Government agencies and international partners. Investments include both competitively awarded and strategically-guided activities to address long-term Agency technology priorities and technology gaps identified within the Agency's space technology roadmaps. Space Technology invests in crosscutting technologies that could benefit human exploration, change the way science missions are conducted and increase efficiency for American industries.

The Space Technology theme also includes the Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR), which encourage small business owners to provide technical innovations. SBIR and STTR continue to support early-stage research and development performed by small businesses through competitively awarded contracts. These programs produce innovations for both Government and commercial applications. SBIR and STTR provide the high-technology small business sector with an opportunity to develop technology for NASA, and commercialize that technology in order to provide goods and services that address other national needs based on the products of NASA innovation. NASA recently selected 260 SBIR Phase I and 85 SBIR Phase II awards, and 40 STTR Phase I and ten STTR Phase II awards.

In all, NASA's Space Technology Program has already funded roughly 1,000 technology projects and engaged thousands of engineers and technologists since its inception in 2011. Several of these projects have hardware ready to test and fly in FY 2013 as they mature their technology for infusion into a future mission or capability. So far in FY 2012, NASA has selected 48 students for Space Technology Research Fellowships. These fellowships allow NASA to engage the next generation of innovators in developing promising technologies supportive of NASA's missions and strategic goals. They join Space Technology's inaugural class of 79 student researchers returning to continue their second year of research. On the International Space Station, we have demonstrated precise maneuvers with the robotic refueling mission, an effort we co-fund with the Human Exploration and Operations directorate at NASA. In addition, we have been remotely controlling robots on the ISS, including Robonaut, NASA's humanoid robot handyman. We have entry, descent and landing sensors riding on board the heat shield of the Mars Curiosity Rover waiting to collect data on the Martian atmosphere during entry. We are excited to see Curiosity reach its final destination on August 6, 2012.

The Nation's first Space-Based Laboratory-Open for Business

The International Space Station (ISS) is fully complete. Many consider it to be one of humanity's greatest technological achievements. Its state-of-the-art research facilities support a wide variety of research disciplines. Examples include high-energy particle physics; Earth remote sensing and geophysics experiments; protein crystallization experiments; human physiology research (including bone and muscle research); radiation research; plant and cultivation experiments; combustion research; fluid research; materials science experiments; and biological investigations. The three major science laboratories aboard the ISS: the U.S. Destiny, European Columbus, and Japanese Kibo facilities, along with external test beds, enable astronauts to conduct experiments in the unique, microgravity and ultra-vacuum environment of LEO, experiments that simply cannot be conducted on Earth. The range of research disciplines that ISS supports means that research and development conducted aboard Station

promises new discoveries not only in areas directly related to NASA's exploration efforts, but in fields that have terrestrial applications, as well.

In the NASA Authorization Act of 2010 (P.L. 111-267), Congress directed that the Agency enter into a cooperative agreement with a not-for-profit organization to manage the activities of the ISS National Laboratory. Last fall, NASA finalized an agreement with the Center for the Advancement of Science in Space (CASIS) to manage the portion of the ISS that operates as a U.S. National laboratory. CASIS will be located in the Space Life Sciences Laboratory at the NASA Kennedy Space Center. This independent, nonprofit, research-management organization will help ensure the Station's unique capabilities are available to a broad cross-section of American scientific, technological and industrial communities.

CASIS will develop and manage a varied research and development portfolio based on U.S. national needs for basic and applied research, establish a marketplace to facilitate matching research pathways with qualified funding sources, and stimulate future interest in using this national lab for research and technology demonstrations and as a platform for science, technology, engineering and mathematics education. The goal is to support, promote and accelerate innovations and new discoveries in science, engineering and technology that will improve life on Earth.

In addition to the direct research benefits to be gained by the ISS as a National Laboratory, this innovative arrangement also supports NASA's effort to promote the development of a LEO space economy. National Lab partners can use the unique microgravity environment of space and the advanced research facilities aboard Station to enable investigations that may give them the edge in the global competition to develop valuable, high technology products and services. Furthermore, the demand for access to the ISS will support the providers of commercial crew and cargo systems. Both of these aspects of the ISS as a National Laboratory will help establish and demonstrate the market for research in LEO beyond the requirements of NASA.

Conclusion

America is beginning an exciting new chapter in human space exploration and scientific discovery. Revolutionizing aerospace science and taking informed risks, NASA and our Nation remain at the cutting edge.

Whether we are developing needed technologies for space exploration or advancing the nation's aeronautics capabilities, great ideas from NASA have a way of spreading to the benefit of everyone. It should come as no surprise, then, that the technologies powering NASA missions are used by pioneering individuals to create and improve products and services that benefit life on Earth. Investments in research and development enable new missions, stimulate the economy, contribute to the Nation's global competitiveness and inspire the Nation's next generation of scientists, engineers and explorers.

As a professor at Cornell University, I have had the honor of working with talented faculty and students who share my passion for space. For most of the past decade, very few of us who have wanted to contribute to the Nation's civil space program have had the opportunity to do so. The desire to engage with NASA is overwhelming. We see this in the fact that OCT receives many more proposals to its solicitations than it can afford to fund. And I have seen it personally, in the hundreds of students who have worked with me on two university-built satellite projects. This experience gave them the skills needed to step into the engineering workforce prepared to problem solve and innovate. NASA must continue to cast a wide net to bring in the best ideas, wherever they may be found.

A NASA focused on advancing technology helps ensure that high-tech jobs will be available for these young people when they complete their studies. And in sponsoring research and development, it will do

its part to encourage the next generation of aerospace engineers, ensuring that our Nation retains the critical capabilities in advanced technology that will ensure its economic competitiveness.

Our Nation's future economic success is tied to our ability to out-innovate the rest of the world. NASA is an important part of this future. America expects boldness from NASA. We are now returning to our innovation roots, taking the long-term view of technological advancement that is essential for accomplishing our missions. America expects no less.

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