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Statement of
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before the

Subcommittee on Space
Committee on Science, Space and Technology
U. S. House of Representatives

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the status of the International Space Station (ISS) Program, as well as our efforts to conduct microgravity research and promote U.S. economic activity in low-Earth orbit (LEO), and expand human spaceflight beyond LEO. The ISS represents an unparalleled capability in human spaceflight that is increasing our knowledge of basic physics and biology. This knowledge is benefiting our lives here on Earth and enhancing the competitiveness of private industry here in the United States. The research and technology demonstrations onboard the ISS are providing the basis for extending human presence beyond the bounds of LEO and taking our next steps into the proving ground of cis-lunar space. With the Administration's proposed extension of the ISS until at least 2024, NASA has the opportunity to more fully utilize research, and commercial and international partnerships to ensure that the U.S. continues to be the world leader in human spaceflight and to enable U.S. industry to realize the commercial benefits of research and development in the microgravity environment of space.

The ISS is vital to NASA's mission to extend human presence into the solar system. In order to prepare for human expeditions into deep space, we must first use the unique environment of ISS to conduct the research and technology demonstrations necessary to keep our crews safe and productive on long-duration spaceflights. The ISS – which has been home to a continuous human presence on orbit for almost 15 years – is NASA's only long-duration flight analog for future human deep-space missions, and it provides an invaluable laboratory for research with direct application to the exploration requirements that address human risks associated with deep-space missions. It is the only space-based multinational research and technology test bed available to identify and quantify risks to human health and performance, identify and validate potential risk mitigation techniques, and develop countermeasures for future human exploration. As NASA learns more about the changes to the human body from spaceflight and develops countermeasures to support long-duration missions, this same research is providing unique insight into problems facing our aging terrestrial population. Through the National Laboratory and the Center for the Advancement of Science in Space (CASIS), U.S. companies are taking advantage of new research opportunities that may provide a competitive edge. Across a range of disciplines and applications, ISS research ultimately benefits people on Earth.

Cargo and Crew Transportation

In order to realize the full potential of the ISS' capabilities, the platform is serviced by a fleet of operational vehicles, including two U.S. cargo resupply vehicles: Space Exploration Technologies'

(SpaceX) Dragon and Orbital ATK's Cygnus. These two providers have flown a combined total of eight cargo missions to the ISS under the Commercial Resupply Services (CRS) contracts, which were awarded on December 23, 2008. The cargo flights have demonstrated the viability of the Government use of commercially provided services – rather than owning and operating the spacecraft and launch vehicles – for the delivery of experiments, supplies, and spares to the Station, enabling NASA to focus its development efforts on deep-space vehicles to take our astronauts beyond LEO. Further, both companies have demonstrated their resourcefulness in dealing with challenges. NASA anticipates awarding one or more CRS-2 contracts later this year.

The overall cargo strategy of having multiple providers has served NASA well, and the importance of having multiple providers is critical for assured cargo access to the ISS, as has been demonstrated by recent losses of Orbital ATK Cygnus, Russian Progress, and SpaceX Dragon cargo flights to ISS. NASA was able to continue ISS operations and research by relying on SpaceX after the Cygnus cargo vehicle anomaly last fall. Orbital is expected to recover and return to flight before the end of 2015. Orbital ATK acquired a launch on an Atlas V vehicle while its Antares launcher is outfitted with a new engine. This strategy allows Orbital ATK to use its Cygnus vehicle and resume cargo delivery capability later this year. The ability of Orbital ATK to quickly integrate Cygnus with an Atlas V is a direct result of their experience in integrating their satellites onto different launch vehicles. The basic CRS-1 contract premise of obtaining cargo services enabled Orbital ATK to creatively acquire a new launch vehicle. This demonstrates the effectiveness of our current contract strategy. Late last month, the SpaceX-7 cargo mission experienced an anomaly during launch. SpaceX has demonstrated extraordinary capabilities in its first six cargo resupply missions to the Station, and we know they can replicate that success. We will work with and support SpaceX to assess what happened, understand the specifics of the failure and correct it to move forward. These events are reminders that spaceflight is difficult, but we learn from each success and each setback, and our commercial cargo program was designed to accommodate the loss of cargo vehicles. With the delivery last week of supplies aboard a Russian Progress vehicle, and with the prospect of a Japanese H-II Transfer Vehicle (HTV) flight in August, we do not anticipate any need to delay the upcoming Soyuz 43S launch later this month, which will return us to six-crew operations and research.

In the area of crew transportation, while NASA continues to develop Commercial Crew capability to provide crew transportation and rescue services to the ISS, the Russian Soyuz spacecraft currently provides these services. The ISS routinely hosts six crewmembers on long-duration missions with the support of two Soyuz spacecraft. The limit in crew size is driven by the Soyuz three-crew-carrying capability. There are currently four Soyuz missions per year to accomplish ISS crew rotations.

NASA's plans for research through 2017 are based having six crew on ISS, including the Human Research Program objectives we need to accomplish during this period to keep on track to reduce or retire risks for deep-space exploration. It should be noted, however, that Station has – from time to time – hosted only three crew during brief transition periods. Before the loss of the SpaceX-7 cargo flight, the current period of three-crew operations had resulted in the deferral of a docking adapter installation, as well as the deferral of some Node 1 preparation tasks. In addition, a rodent experiment was dropped from the SpaceX-7 cargo flight, and some fluid shift experiments were moved to the next Expedition. At this point, NASA anticipates that the current period of having three crew aboard will not last longer than a few weeks, after which, we will staff back up to six crew and resume the normal rate of research activities. Beyond 2017 when U.S. crew providers come on line, our plans count on having an ISS crew complement of seven. Even after losing the docking adapter on SpaceX-7, NASA will have time to add docking capability to ISS to support the first U.S. commercial crew flights.

In 2014, NASA contracted with two U.S. providers for crew transportation and rescue services for ISS. The Commercial Crew Transportation Capability (CCtCap) contracts will complete the development of

domestic systems to provide safe, reliable, cost-effective access to and from ISS. SpaceX's Crew Dragon and Boeing's CST-100 spacecraft will begin ferrying our crews to Station from U.S. soil by the end of 2017, contingent upon receiving the full amount requested in the FY 2016 Budget Request, enhancing the robustness of our transportation system and ending our sole reliance on Russia for the provision of these services. U.S. commercial crew capabilities will enable the Station crew to be expanded from six to seven astronauts and cosmonauts, resulting in a doubling of on-orbit research time to almost 80 hours per week. This is because the seventh crew member will be able to focus his or her time almost exclusively on conducting experiments, rather than on Station operations and maintenance.

I want to thank this Committee for authorizing full funding in FY 2016 for our Commercial Crew Program. It is vitally important that NASA receive this funding level to keep the development of these systems on track for flights in 2017. If the Agency is funded with a Continuing Resolution for the first quarter of FY 2016, NASA will need to address how it will fund our partners' development activities at the current contractual schedule. The CCtCap contractors are only required to work on milestones to the extent that NASA has obligated funding for those milestones. If funding is not available in FY 2016 for the initial FY 2017 milestones, the contractors will have to stop work or work at risk until additional funding can be obligated, existing CCtCap contracts will need to be renegotiated, most likely resulting in schedule delays and increased contract cost, and NASA will need to continue to rely solely on Russian Soyuz capability to meet America's requirements for crew transportation services. NASA has no plans to downselect the number of partners in response to lower-than-requested funding levels. As experience has shown with cargo, NASA's plan to establish a redundant crew transportation capability is critically important for robust, safe ISS operations. This redundancy is even more critical during the development phase. We appreciate the Committee's support for our plan to end sole reliance on Russia for crew transportation through contracts with two U.S. providers.

With over 350 American companies across 36 states working toward this goal, there are significant economic benefits to returning these launches to American soil. At the same time, every dollar we send overseas rather than investing at home represents an investment we could be making in ourselves rather than in the Russian economy.

There are also longer term fiscal considerations to consider. NASA projects that the average seat price will be $58 million per seat for Commercial Crew. The currently contracted seat price for Soyuz for 2017 is approximately $76 million per seat.

Sustainability of ISS and Extension to 2024

The ISS continues to be a very healthy system operating well within prudent technical margins, and consistently demonstrating outstanding steady-state performance that meets or exceeds prior engineering estimates. While systems were originally specified to be both reliable and maintainable, the operational experience NASA and its Partners are gaining is providing invaluable information on reliability and maintainability standards for future application to spacecraft design and mission planning. This enables systems needed for long-duration spaceflight to be tested in preparation for missions far from Earth for which reliability and maintainability are absolutely required. Just as short-duration Space Shuttle flights prepared us for long duration Station flights, ISS is preparing us for missions that will not have the option of immediate crew return in the event of an anomaly.

In January 2014, the Administration announced its intent to extend ISS operations until at least 2024. The research we will conduct on ISS through 2024 will be essential to the safe and effective conduct of human exploration beyond LEO. This extension is also critical to commercial sector planning for the use of the ISS. Industry requires the planning stability provided by the extension in order to consider further

investment in microgravity research and transportation services. Commercial LEO development, spurred in part by the continuation of ISS, will also help enable exploration and make NASA resources available for deeper space exploration.

In addition to the United States, the Government of Canada has announced that Canada will continue its participation in the ISS to 2024. There have been multiple public indications that Russia will continue participating in the ISS program through 2024; Roscosmos (the Russian Federal Space Agency) has publicly commented that it expects to receive government authority by the end of the year to continue ISS beyond 2020. The Government of Japan has also indicated that its decision to support ISS operations beyond 2020 will likely be made in the near future after internal government deliberations are completed. The European Space Agency is expected to address ISS operations and utilization beyond 2020 at their ministerial meeting in late 2016. The ISS Partners have expressed support for continuing research on ISS, and see tremendous benefit for extended research opportunities.

As NASA has moved into Station's intensive utilization phase, we have become more cost-efficient in ISS operations. In the FY 2016 President's Budget Request, ISS Operations and Maintenance (O&M) is only 35 percent of the ISS request. The majority of the request, 55 percent, is for ISS Crew and Cargo Transportation. The remaining 10 percent is for ISS Research. Since the ISS was extended to 2020 in 2011, NASA has reduced the ISS O&M budget through a combination of efficiencies in sustaining activities, some content reductions, and cutbacks in operations overhead. While NASA continues to look for further efficiencies, we have already achieved a level of efficiency that allows us to productively operate and sustain the ISS, keep our crews healthy and safe, and support utilization with substantially reduced resources. Ongoing activities to responsibly lower the O&M cost of the ISS include changes to our contracts to incentivize efficiency, lower overhead cost, and apply targeted enhancements in technology investments to reduce manpower-intensive processes. These activities are assumed in the FY 2016 President's Budget Request.

ISS Research

The ISS supports research across a diverse array of disciplines, including high-energy particle physics, Earth remote sensing and geophysics experiments, molecular and cellular biotechnology 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. In addition, the ISS is an invaluable platform for technology development efforts. Research and development conducted aboard the ISS holds the promise of next-generation technologies, not only in areas directly related to NASA's exploration efforts, but in fields that have numerous terrestrial applications. The ISS will provide these opportunities to scientists, engineers, and technologists through at least 2024. Beyond being a feat of unparalleled engineering and construction, as well as international collaboration, the ISS is a place to learn how to live and work in space over a long period of time and foster new markets for commercial products and services. Remarkably, 83 countries/areas worldwide have participated in ISS utilization.

NASA's Human Research Program continues to develop biomedical science, technologies, countermeasures, diagnostics, and design tools to keep crews safe and productive on long-duration space missions. The progress in science and technology driven by this research could have broad impacts on Earth as it advances our ability to support long-duration human exploration.

On March 27, 2015, NASA astronaut Scott Kelly and cosmonaut Mikhail Kornienko of Roscosmos launched to the ISS to begin a one-year mission aboard the orbiting outpost. NASA and Roscosmos selected several collaborative investigations for this mission to evaluate the effects of long-duration

spaceflight on humans. Each of the U.S. investigations will be grouped into one of seven categories: functional, behavioral health, visual impairment, metabolic, physical performance, microbial, and human factors. Researchers expect the mission's investigations to provide data on biomedical, performance, and behavioral changes and challenges astronauts may face when they embark on longer-duration missions, like those to an asteroid, Mars, or beyond. Data from the expedition will be used to determine whether there are ways to further reduce the risks on future long-duration missions to an asteroid and eventually Mars.

The investigations involving astronauts Scott and Mark Kelly, who are identical twins, will provide NASA and outside researchers with a genetic blueprint and broader insight into the subtle genetic effects and changes that may occur during long-term (i.e., one year) spaceflight as compared to Earth-based environments. The studies will focus on four areas: human physiology, behavioral health, microbiology/microbiome, and molecular or -omics studies (-omics refers to a system-level approach to studying molecular biology; examples include genomics, proteomics, and metabolomics). Although the investigations conducted on the Kelly brothers are not expected to provide definitive data about the effects of spaceflight on individuals — because there are only two subjects for data collection — they do serve as a demonstration project for future research initiatives. These investigations may identify changes to pursue in research of larger astronaut populations.

NASA is also exploring open-source science where databases are made available to a large number of researchers for investigation. This approach is in contrast to the past practice of one researcher "owning" all of the data from their investigation. This open-science approach shares a large data set of information with researchers for a variety of investigations

A National Laboratory in Orbit

In the NASA Authorization Act of 2005 (P.L. 109-155), Congress designated the U.S. segment of the ISS as a National Laboratory, and directed the Agency to seek to increase the utilization of the ISS by other Federal entities and the private sector. Subsequently, 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. On August 31, 2011, the Agency finalized a cooperative agreement with CASIS to manage the portion of the ISS that operates as a U.S. National Laboratory. CASIS works to ensure that the Station's unique capabilities are available to the broadest possible cross-section of U.S. scientific, technological, and industrial communities. The goal is to support, promote and accelerate innovations and new discoveries in science, engineering, and technology that will improve life on Earth. NASA's National Laboratory 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. The National Laboratory will help establish and demonstrate the market for research in LEO beyond the requirements of NASA.

Use of the ISS as a National Laboratory has increased significantly since FY 2012, which was the first full year of operations by CASIS. CASIS is reaching its full allocation of National Lab resources and it expected to continue to do so for the foreseeable future. The growth is coming from non-traditional areas, specifically from the commercial sector. Commercial projects for research and technology development on the ISS National Lab have increased from three in FY 2012 to 107 in FY 2014. This includes such industry leaders as Merck, Novartis, and Eli Lilly. Expanded capabilities, such as the ability to conduct model organism research on the ISS, using rodents as well as other organisms, has helped draw this interest. Commercial efforts have also included perhaps the largest purely commercial provision of services using the ISS, the deployment by NanoRacks of dozens of Dove cube satellites for Planet Labs.

Similarly, use by other Government agencies, including the National Institutes of Health and Department of Defense, has also begun to broaden, totaling 11 investigations in FY 2014. Finally, investigations from academic institutions rose from 31 in FY 2012 to 90 in FY 2014. Grant funding for research through the National Lab continues to grow, from $2.1 million in FY 2012, to $5.9 million in FY 2014. Additionally, NASA is collaborating with CASIS to enable sustained investment and research activities onboard the ISS across industry and other Government agencies that will transcend the life of the Station. The ISS International Partners are also seeking to expand the base of researchers using their assets on the ISS and are very interested in the National Lab model. This will expand research, and commercial participation, in low-Earth orbit.

ISS – Benefits to Humanity

Almost as soon as the ISS was habitable, researchers began using it to study the impact of microgravity and other space effects. In the physical and biological sciences arena, the ISS allows researchers to use microgravity conditions to understand the effect of the microgravity environment on microbial systems, fluid physics, combustion science, and materials processing, as well as environmental control and fire safety technologies. The ISS also provides a test bed for studying, developing, and testing new technologies for use in future exploration missions. Although each Station partner has distinct agency/national goals for ISS research, each partner collectively shares a unified goal to extend the resulting knowledge for the betterment of humanity. In the areas of human health, telemedicine, education, and Earth observations from space, there are already demonstrated benefits. Pharmaceutical development research, Station-generated images that assist with disaster relief and farming, and education programs that inspire future scientists, engineers, and space explorers highlight just some of the many examples of research that can benefit humanity.

ISS crews are conducting human medical research to develop knowledge in the areas of: clinical medicine, human physiology, cardiovascular research, bone and muscle health, neurovestibular medicine, diagnostic instruments and sensors, advanced ultrasound, exercise and pharmacological countermeasures, food and nutrition, immunology and infection, exercise systems, and human behavior and performance. Many investigations conducted aboard ISS will have direct application to terrestrial medicine. For example, the growing senior population may benefit from experiments in the areas of bone and muscle health, immunology, vestibular response and balance, and from the development of advanced diagnostic systems. The ISS requires telemedicine be used to monitor and treat crews. Optical Computerized Tomography (OCT), fundoscopy, and tonometry are now routinely used onboard the ISS to diagnose and monitor any progression of Visual Impairment Intracranial Pressure (VIIP) syndrome. The ISS Ultrasound aides in the remote diagnosis of a variety of conditions ranging from musculo-skeletal issues and abdominal pains to infection of soft tissues. Similar equipment and techniques can be used on Earth to provide medical care to patients without requiring their travel to a hospital or doctor.

The ISS also plays an important role in promoting education in the science, technology, engineering, and mathematics (STEM) fields, inspiring students to pursue scientific and technical careers. Astronauts aboard ISS participate in educational downlinks with schools, and engage in communicating with people around the world using “ham” radio. The ISS Program also conducts experiments that involve student participation. One example is the Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) facility. SPHERES are three bowling-ball sized spherical satellites that are used inside the Station to test telerobotics operations in addition to spacecraft formation flight and autonomous rendezvous and docking maneuvers. NASA, along with the Defense Advanced Research Projects Agency, with implementation by the Massachusetts Institute of Technology, has co-sponsored “Zero Robotics SPHERES Challenge” competitions for high school and middle students from the U.S. and abroad. The competitions challenge students to write software code, which is uploaded to the robots on

ISS, and the SPHERES satellites then execute the instructions, in areas such as formation flight and close proximity operations. Student finalists were able to watch their flight program live on NASA-TV.

Conclusion

The ISS has now entered its intensive research and technology demonstration phase. Station will continue to meet NASA's mission objective to prepare for the next steps in human space exploration. Closer to home, NASA's National Laboratory 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 enables the establishment of robust U.S. commercial crew and cargo capabilities. Both of these aspects of the U.S. segment of the ISS as a National Laboratory will help establish and demonstrate the market for research in LEO beyond the requirements of NASA.

With NASA as the lead integrator on ISS for the international partnership, the ISS allows the U.S. to demonstrate global leadership in human spaceflight and technology development. ISS and the teams that operate it are an amazing global resource.

NASA appreciates this Committee's ongoing support of the ISS as we work together to support this amazing facility which yields remarkable results and benefits for the world.

Mr. Chairman, I would be happy to respond to any questions you or the other Members of the Subcommittee may have.