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Statement of
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Subcommittee on Space
Committee on Science, Space and Technology
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Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the future of the International Space Station (ISS). As you know, the ISS serves as a unique platform to prepare for human exploration beyond low-Earth orbit (LEO), promote U.S. economic activity in space, and conduct innovative research and technology development. Equally important, under the leadership of the United States, the ISS contributes to America's preeminence around the world in space and technological innovation. Since its inception over 30 years ago, the ISS international partnership has been a model of peaceful cooperation through difficult times.

The ISS represents an unparalleled capability in human spaceflight that is increasing our knowledge of fundamental physics, biology, the Earth, and the universe. This knowledge is benefiting our lives here on Earth and enhancing the competitiveness of U.S. private industry. The research and technology demonstrations onboard the ISS are not only providing the basis for extending human presence beyond the bounds of LEO and taking our next steps into the proving ground of cislunar space, but also advancing the competitiveness of U.S. private industry.

We appreciate the action Congress took in 2015, reaffirmed in this year's legislation, regarding continued Station operations through at least 2024, and are pleased to note that all of the International Partners have agreed to participate through at least 2024, as well. NASA has the opportunity to continue to utilize ISS for research, 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 space. As we consider the future of ISS and U.S. leadership in space, it is helpful to review the benefits provided by Station to exploration, space commercialization, and terrestrial applications.

Preparing for Human Deep Space Missions

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 ISS to conduct breakthrough research and test the advanced technology necessary to keep our crews safe and productive on long duration space exploration missions. The ISS – which has been home to a continuous human presence on orbit for over 16 years – is NASA's only long-duration flight analog for future human deep-space missions. It is an

invaluable space laboratory for exploration research that addresses human health and performance risks associated with future deep-space missions.

Work in support of exploration missions includes biomedical research and the development of new human health capabilities. NASA's Human Research Program (HRP) continues to develop biomedical science, technologies, countermeasures, diagnostics, and tools to keep crews safe and productive on long-duration space missions. An on-orbit platform like the ISS is necessary to mitigate 22 of the 33 human health risks in the HRP portfolio. With the certainty of an ISS lifetime through at least 2024, HRP will have the tools necessary to make great progress toward mitigating the majority of exploration health and performance risks. In the event that not all risk areas have been mitigated by the end of ISS' operational life, NASA will assess the potential impacts and the best way to address them, given the available knowledge. 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. NASA is also using the ISS as a testbed to fill critical gaps in technologies that will be needed for long-duration deep space missions. For example, elements of the ISS life support and other habitation systems, along with contributions from private sector firms, will evolve into the systems that will be used for deep space exploration missions. It is NASA's plan to first develop and demonstrate many critical technology capabilities using the ISS as a permanently-crewed testbed prior to deploying these capabilities beyond LEO. This approach is much more cost-effective and faster than conducting this research in cislunar space because of the higher costs inherent in operating so far from the Earth.

The strength of the international partnership created through the ISS Program is a testament to U.S. leadership in space and to the aerospace expertise of all the nations involved. It serves as a robust example of how many countries can work together to design, build, operate, and maintain large, complex human space assets. As we consider the future of ISS and prepare for human missions of exploration into deep space, it is important to reflect on the practical value of the proven partnership that has made the ISS possible, and to consider how we may build on these relationships as we proceed into cislunar space.

Supporting LEO Commercialization

Through public-private partnerships centered around the ISS platform, NASA is supporting the development of a commercial space economy in LEO.

The Center for the Advancement of Science In Space (CASIS) manages the activities of the ISS National Laboratory to increase the utilization of the ISS by other Federal entities and the private sector. 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 and expand commercial activities and markets in space. ISS 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 ISS National Laboratory is helping to establish and demonstrate the market for research, technology demonstration, and other activities in LEO beyond the requirements of NASA.

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 extension of ISS operations to at least 2024 was very important to commercial sector planning for the use of the ISS National Laboratory. The timeliness of this decision by the Administration and Congress was extremely important. Industry required the planning stability provided by the extension in order to

consider further investment in microgravity research and transportation services. This timely decision allowed time to begin enabling and maturing emerging commercial LEO markets.

Under the Commercial Resupply Services (CRS) contracts, NASA's two commercial cargo partners, Space Exploration Technologies (SpaceX) and Orbital ATK, have demonstrated not only the ability to provide cargo deliveries to ISS, but also the flexibility to recover effectively from mishaps. In January 2016, through CRS-2, NASA contracted with SpaceX, Orbital ATK, and Sierra Nevada Corporation to ensure that critical science, research, and technology demonstrations will be delivered to the ISS from 2019 through 2024.

NASA's commercial crew partners, SpaceX and the Boeing Company, are developing the Crew Dragon and CST-100 Starliner spacecraft, respectively. These companies have made significant progress toward returning crew launches to the U.S., and NASA anticipates having these capabilities in place by 2019 to regularly fly astronauts safely to and from ISS. The crew and cargo vehicles, as well as the launch vehicles developed by these providers, have the potential to support future commercial enterprises as well.

The Administration views public-private partnerships as the foundation of future U.S. civilian space efforts. NASA is continuing to develop cooperation on use of the Station to enable increased commercial investment and to transition to more public-private partnership models. For example, NanoRacks and Boeing have partnered to provide a commercial airlock on the ISS, and NASA is studying how to implement other commercial capabilities such as private modules or external facilities. In addition, NASA has begun to transition from a model where NASA provides payload integration and other services to one where those services can be purchased from one of many commercial partners. For example, the Made In Space, Inc. commercial Additive Manufacturing Facility (AMF) aboard ISS enables NASA and National Laboratory users to obtain 3D printing services on orbit. The ability to print on orbit has the potential in NASA's exploration activity to reduce the quantity of parts and tools carried as supplies – needed parts could simply be printed. Printing in space in microgravity has the potential to enable commercial companies to manufacture parts with higher purity or even to print biological material without the need to counteract gravity during printing. The ISS has also played a role in the development of CubeSats, which are small satellites measuring about four inches on a side that can be combined and configured to support a variety of research objectives for commercial companies, educational institutions, and non-profit organizations. CubeSats offer opportunities to conduct scientific investigations and technology demonstrations in space in such a way that is cost-effective, timely, and relatively easy to accomplish. Approximately 150 CubeSats have been deployed from ISS. As stated in the President's FY 2018 Budget Blueprint, NASA will also be working to create new opportunities for collaboration with industry on space station activities.

Benefitting Humanity

Across a range of disciplines and applications, ISS research ultimately benefits people on Earth. 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. In the areas of human health, telemedicine, education, and Earth observations from space (including those anticipated from the recently delivered Stratospheric Aerosol and Gas Experiment III [SAGE III]), there are benefits that have already been demonstrated, such as robotic microsurgery techniques and water purification technologies used in developing regions. Pharmaceutical studies and Station-generated images that assist with disaster relief and farming are just two of the many examples of Station activities 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 effects, diagnostic instruments such as advanced ultrasound, exercise and pharmacological countermeasures, food and nutrition, immunology and infection, exercise systems, human behavior and performance, and visual impairment intracranial pressure. Many investigations conducted aboard ISS will have 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 telemedicine techniques used to monitor and treat ISS crews. These telemedicine capabilities can be used on Earth to improve medical care to patients without requiring 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. In addition to research- and technology-related educational opportunities, astronauts aboard ISS participate in educational downlinks with schools, engage in communicating with people around the world using "ham" radio, and conduct experiments that involve student participation.

Options for the Future

The ISS continues to be a healthy system that is operating well within prudent technical margins while consistently demonstrating outstanding steady-state performance that meets or exceeds prior engineering estimates. U.S.-built Station modules were designed for a 30-year on-orbit lifetime, and the lifetime extension data that NASA and the ISS Partnership have reviewed to date indicates that extension to 2028 is technically feasible. Further, as NASA has moved into Station's intensive utilization phase, we have become more cost-efficient in ISS operations and continue to look for further efficiencies.

It is timely to begin discussions on the future of ISS. In the NASA Transition Authorization Act of 2017, Congress requests a plan from NASA to transition ISS from the current regime that relies heavily on NASA sponsorship to a regime where NASA could be one of many customers of a LEO non-governmental human space flight enterprise. NASA has been building a strategy and assessing options that supports this vision for the future of human spaceflight in LEO. These options include: extension of ISS beyond 2024 as-is, revising the current ISS operating model to shift to a more commercial model, maintaining and transitioning pieces of the ISS to a commercial platform, and de-orbiting portions of the ISS or the entire spacecraft.

Some of the key considerations in assessing these options are: whether critical deep-space technologies and systems have been demonstrated; whether human health risks for deep space missions have been mitigated; whether NASA is executing human missions beyond LEO; whether alternative platforms for conducting necessary research and technology development are becoming available; the interest among NASA's international partners either to extend or terminate the existing ISS financial and operational arrangements; changes to the current assessment of the technical feasibility of extending the platform beyond 2024; the demand outside of NASA in private industry and other government agencies for ISS capabilities; and the amount of time required for ISS maintenance vs. research time. Whichever option is ultimately chosen, in consultation with the ISS partnership, it is critical that we maintain continuity in U.S. human spaceflight and America's leadership in space and technology innovation.

NASA is engaged with several commercial partners to advance and test a variety of habitation technologies. This Next Space Technologies for Exploration Partnerships (NextSTEP) activity, plus

related technology developments and partnerships, will enable deployment of a deep space habitation capability in the mid-2020s, which in turn will validate systems needed for more challenging human future deep space activities. NASA and industry will identify commercial capability development for LEO that intersects with the Agency's long duration, deep space habitation requirements, along with any options to leverage commercial LEO advancements towards meeting NASA long duration, deep space habitation needs while promoting commercial activity in LEO. The Agency is working with industry to define common interests between LEO and deep space habitation systems, architectures, requirements, common interfaces and standards, and invest in technology maturation efforts. NASA is conferring with industry to inform deep space habitation requirements while maximizing commercial capabilities for LEO.

NASA is investigating concepts for habitats that can keep astronauts healthy during space exploration. Expandable habitats are one such concept under consideration – they require less payload volume on a rocket than traditional rigid structures, and expand after being deployed in space to provide additional room for astronauts to live and work inside. The Bigelow Expandable Activity Module (BEAM) is the first test of such a module attached to the ISS. It will allow investigators to gauge how well it performs overall, and how it protects against space radiation, space debris and the temperature extremes of space. BEAM was filled with air and expanded in May 2016. Astronauts are entering BEAM on an occasional basis to conduct tests to validate the module's overall performance and the capability of expandable habitats.

NASA is actively developing transition strategies for the concurrent- and post-ISS LEO era and is engaged with the private sector to foster both private demand and supply for LEO services. It is NASA's intention to continue to foster the development of private industry capabilities and private demand. Once these private capabilities are available, NASA intends to be one of many customers, including both private and other Government agencies, for LEO platforms. The Agency welcomes input from other stakeholders on how best to enable future private LEO platforms and the development of a commercial market in LEO.

Conclusion

The ISS has now entered its intensive research and technology demonstration phase and is enabling a maturing commercial market. The maturity and stability of the ISS Partnership allows the U.S. to demonstrate global leadership in human spaceflight and technology development and is already providing the foundation for continuing human spaceflight beyond LEO. Closer to home, NASA's ISS National Laboratory partners can use the unique capabilities aboard Station to enable investigations that may give them the edge in developing valuable, high technology products and services for the global market. 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 ISS National Laboratory will help establish the U.S. market for research in LEO beyond the current NASA requirements.

While the future of ISS will require both careful consideration and advance planning, we have a few years yet to allow the Program to continue to produce results, and for potential markets for commercial facilities in LEO – which will take time to develop – to evolve before committing to a specific course of action, in consultation with the ISS partners. In the coming years, we will be able to make a well-grounded assessment, but for now, the crews aboard ISS will continue paving the way for future deep space missions, supporting the growth of commercial activities in LEO, and providing benefits to people on Earth.

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.