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**Statement of**

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**before the**

**Senate Committee on Commerce, Science and Transportation**
**Subcommittee on Space, Science, and Competitiveness**

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) and NASA's long-term vision for use of low-Earth orbit (LEO).

NASA is preparing to secure the Nation's long-term presence in LEO by partnering with industry to develop commercial orbital platforms, and capabilities that the private sector and NASA can utilize after the cessation of direct U.S. Federal funding for ISS by 2025.

To be clear, NASA is not abandoning LEO. We must ensure the right pieces are in place to maintain an operational human presence in LEO, whether through a modified ISS program, commercial platforms, or some combination of both.

In October of last year, the members of the National Space Council endorsed a recommendation to the President that NASA should return to the Moon. Following that recommendation, on December 11, 2017, the President signed Space Policy Directive 1 which requires NASA to "*Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities.*" This was nearly 45 years to the moment since the last time that NASA landed humans on the Moon.

NASA will shift the focus of its human exploration program to the Moon and cislunar region with an eye towards Mars, evaluating new habitat technologies, surface transportation systems, landing systems, fuel generation, and storage solutions. In every domain, we intend to renew and strengthen our commitment to American commercial space companies, which are critical partners in the human exploration of the Moon, Mars, and beyond. As NASA reorients the human spaceflight program back to the Moon and beyond to Mars, we will push to develop new ways of operating in LEO that will benefit our exploration endeavors, science goals, and ultimately the taxpayers.

As you know, the ISS currently serves as a unique platform to prepare for human exploration beyond LEO, promotes U.S. economic activity in space, and accelerates 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 partnership has been a model of peaceful international cooperation. ISS has exceeded all of its original goals and accomplished many things that were never envisioned. Things like

helping to establish a cube satellite market and helping to return commercial satellite launches to the U.S. through reduced launch costs. However, NASA must look beyond ISS in its current form in order to continue U.S. leadership in LEO; that is why the NASA Transition Authorization Act of 2017, together with the Administration, are united in transitioning NASA's LEO activities to a model where NASA is one of many customers of a vibrant, U.S.-led, commercial LEO enterprise. The synergy between industry and Government requirements in this endeavor cannot be overstated. We are partners in ensuring American preeminence as the world's leading spacefaring nation.

The Administration views public-private partnerships as the foundation of future U.S. civilian space efforts, and 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, the Agency has begun to transition from a model where NASA provides payload integration and other services to one where those services can be purchased from many commercial partners.

As we consider the future of the ISS and U.S. leadership in space, it is helpful to review the benefits provided by U.S. leadership in LEO to exploration, space commercialization, and terrestrial applications.

**Preparing for Human Deep Space Missions**

In order to prepare for human expeditions into deep space, the Agency must first conduct breakthrough research and test the advanced technology necessary to keep crews safe and productive on long-duration space exploration missions. On-orbit platforms are necessary to mitigate 22 of the 33 human health risks in the portfolio identified by NASA's Human Research Program in support of current and future deep space missions. The research to mitigate these risks must continue beyond 2025 to ensure that we learn what is necessary to travel deeper into space and to live and work in microgravity for long durations. This requirement will not go away no matter what orbital platforms are used.

NASA also plans to continue to use LEO facilities as testbeds 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 will be evolved into the systems that will be used for deep space exploration missions and undergo long-duration testing. It is NASA's plan to first develop and demonstrate many critical technology capabilities using LEO platforms 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 risks inherent in operating so far from the Earth.

As both research and technology development requirements evolve, NASA will look to take advantage of additional platforms in LEO as a way to accelerate development timetables. If there are cheaper and more efficient ways to meet these requirements, NASA is prepared to utilize them.

**Enabling a LEO Commercial Market**

NASA's vision for LEO is a sustained U.S. commercial human spaceflight marketplace where NASA is one of many customers. We envision multiple privately-owned/operated platforms – human-tended, permanently-crewed, or robotic – together with transportation capabilities for crew and cargo that enable a variety of activities in LEO, where those platforms and capabilities are sustained to a greater degree than today by commercial revenue. These future platforms may either leverage ISS or be free-flying. This flexibility allows the private sector to determine how best to meet the market demand rather than have the Government dictate how to meet this demand.

NASA must also communicate our forecasted needs in LEO to allow the private sector to anticipate that demand in their business cases. The Administration has proposed 2025 as the date by which direct

Federal support of ISS will end; setting this date provides market clarity for our commercial LEO supply partners. At the last National Space Council meeting at Kennedy Space Center, the Vice President asked the NASA Administrator to work with the secretaries of State and Commerce to develop a strategy for how we can further enable cooperation with our international and private industry partners to continue to develop the infrastructure and policies necessary to spur economic growth in space. That work is ongoing and we plan to deliver some of those recommendations at the fall meeting of the Council.

In this vision, NASA would be able to share the cost of LEO platforms with other commercial, Government, and international users. This would allow NASA to maximize its resources toward missions beyond LEO, while still having the ability to utilize LEO for its ongoing needs for research, training, and technology development.

In order to enable this vision, NASA is not only executing several public-private partnerships, currently centered around the ISS, to foster the development of customers for LEO capabilities, but also is maturing the supply industry to be able to meet future demands. NASA is also initiating the Commercial LEO Development program to further the development of commercial on-orbit capabilities beyond what is available today through the ISS.

The Commercial Resupply Services (CRS) contracts, the Commercial Crew Program, and the ISS National Laboratory are key complementary activities to enable this vision. Under the 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. The addition of the Sierra Nevada Corporation as a third commercial service provider will add significant on-orbit and return capability. Both Orbital ATK and Sierra Nevada Corporation have begun to investigate options to perform significant on-orbit operations after their primary cargo mission is completed. These two providers are able to provide an on-orbit research capability independent of ISS. 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 as ISS.

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 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. Commercial implementation partners are now bringing their own customers to LEO through the National Laboratory, as well.

**ISS Transition**

In the NASA Transition Authorization Act of 2017, Congress requested 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 spaceflight enterprise. NASA has been building a strategy and assessing options that support this vision for the future of human spaceflight in LEO, and this is reflected in the ISS Transition Report, delivered to Congress in late March of this year. NASA anticipates that the ISS is capable of continuing to operate within prudent technical margins and its lifetime could exceed original engineering estimates. This is a testament to American ingenuity and technological prowess.

However, complacency is the enemy of progress in technology development. We must continue to push the boundaries of what we believe is possible, not just for NASA but for the entire space industry. NASA is ready to ensure that LEO is open for American business and that our international partners have a role to play in lunar development. The development of commercial space operations in LEO will benefit NASA as we continue to utilize those capabilities to do the things that only NASA can do in exploration. Those principals are two sides of the same coin – they operate together and are not mutually exclusive.

As we contemplate what will happen in this transition, it is important that we remember lessons learned from the ISS and continue to build on them for the next phase of NASA's involvement in LEO and beyond. This transition is an opportunity to demonstrate to the world that U.S. leadership in space is not about one program, but about the qualities that make us the greatest spacefaring nation on the planet. Our insistence that the industry has the ability to respond to Government imperatives and that our international partners can count on us to lead the next generation of capabilities in LEO and beyond will light the way for this next phase of human exploration.

*ISS Transition Principles*

Several key principles will be reflected in any strategy or decision regarding the ISS and the future of LEO, as well as NASA's role as one of many customers of services or capabilities that are provided by private industry as part of a broader commercial market. The following principles will ensure uninterrupted access to LEO capabilities and long-term national interests in human space exploration, while supporting national security objectives, such as a competitive industrial base and U.S. leadership:

- Expanding U.S. human spaceflight leadership in LEO and deep space exploration, including continuity of the relationships with our current ISS international partners;
- Increasing platform options in LEO to enable more ISS transition pathways, security through redundant capabilities, and industrial capability that can support NASA's deep space exploration needs;
- Spurring vibrant commercial activity in LEO;
- Continuing to return benefits to humanity through Government-sponsored basic and applied on-orbit research;
- Providing continuity among NASA's LEO, deep space exploration, and development and research activities and missions toward expanding human presence into the solar system;
- Maintaining critical human spaceflight knowledge and expertise within the Government in areas such as astronaut health and performance, life support, safety, and critical operational ground and crew experience;
- Continuing Government-sponsored access to LEO research facilities that enable other Government agencies, academia, and private industry to increase U.S. industrial competitiveness and provide goods and services to U.S. citizens; and
- Continuing to reduce the Government's long-term costs through private industry partnerships and competitive acquisition strategies.

*ISS Transition Strategy*

As part of a cohesive exploration strategy, NASA intends to meet its needs and requirements in LEO by leveraging private industry capacity, innovation, and competitiveness that could offer the prospect of lower cost to the U.S. Government, while at the same time expanding the economic sphere of U.S. industry into LEO and beyond. This could enable NASA to apply more personnel and budget resources

to expanding human space exploration beyond LEO and enhancing U.S. leadership in human spaceflight around the world. Beyond the prospect of lower operational costs for a LEO platform, shifting focus to industry can additionally reduce the infrastructure burden on NASA, which could reduce operations and maintenance costs.

In order to ensure that private industry is prepared to provide the services and capabilities that support NASA's needs in LEO, as outlined in the key principles above, and to enable private industry to develop markets and customers beyond the Government, NASA is proposing the following approach:

1. Begin a step-wise transition of LEO human spaceflight operations from a Government-directed activity to a model where private industry is responsible for how to meet and execute NASA's requirements. Consistent with the *ISS Transition Principles*, this does not mean NASA is "commercializing the ISS." Instead, NASA maintains U.S. Government leadership and responsibilities as outlined in the Partnership agreements, and continues to maintain the essential elements of human spaceflight, such as astronaut safety and the high-risk exploration systems.

   This will give NASA time to engage with industry to begin transforming the many NASA-directed activities that are currently performed through several contracts into more of a public-private partnership and/or services contract(s) model where NASA's current responsibilities are executed and managed by private industry. This time period will also provide the opportunity for NASA and private industry to engage with stakeholders and to only proceed when industry has matured and is capable of executing NASA's requirements. The transition of ISS will ensure that there are private companies with the experience and expertise to operate various types of platforms in LEO by the mid-2020s. This transition to private industry must be done in a cost-effective manner and not exceed current operational costs.

   Consistent with the *ISS Transition Principles*, NASA will continue discussions with the ISS international partners to help shape the long-term future of LEO.

2. Solicit information from industry on the development and operations of private on-orbit modules and/or platforms and other capabilities that NASA could utilize to meet its long-term LEO requirements that are consistent with the *ISS Transition Principles*. The scope of the solicitation may include risk reduction development activities, or modules or elements that could either be attached to the ISS or be free-flying. The solicitation may also include private-industry-conducted studies on the future of the ISS platform that may be combined with private industry objectives in LEO.

   NASA began with a solicitation in FY 2018 to gather broad industry input on interest in meeting NASA's long-term needs and objectives that should lead to multiple awards in FY 2019 funded out of the Commercial LEO Development program.

3. NASA will also be working with the Department of Commerce to investigate opportunities to facilitate and enable private industry to develop new market opportunities in LEO. It is important that U.S. industry discover the global competitive advantage of utilizing space for research and revenue-generation activities. This ultimately allows NASA to be one of many customers.

*ISS Considerations and the Eventual Future of the ISS Platform*

From a structural integrity analysis standpoint, the ISS platform is expected to have significant structural life well beyond 2028 (based on the current assessment period). Many of the ISS modules, particularly the modules launched in the later years of ISS assembly, are likely to have structural life well into the 2030s. Although it is thus likely technically feasible to continue to operate the ISS well beyond 2028

with continued maintenance, it is also necessary to consider the current high costs of operating this complex facility. The ISS lifetime must also be considered in the context of what our national priorities are for a robust LEO economy. The LEO economy is unlikely to reach its full potential if the Federal Government is the sole supplier of LEO research capabilities.

The future of the ISS will be evaluated using the *ISS Transition Principles* to ensure there is no gap in the availability of a LEO platform to meet NASA's needs, whether this means transitioning the operations of the ISS to private industry through public-private partnership, augmenting the ISS with privately developed modules, combining portions of the ISS with a new private platform, or de-orbiting the ISS and beginning anew with a free-flying platform.

Decisions about the future of the ISS will be discussed across the ISS international partnership. The partners agree on common themes for considering the future of ISS and exploration, including:

- Reducing operational costs;
- Offering frequent visible national astronaut opportunities;
- Continuation and continuity of research and technology development activities;
- Building synergies between LEO and exploration activities; and
- Support of commercial opportunities.

*NASA's Long-Term LEO Requirements*

NASA and the U.S. have a long history of human spaceflight leadership and LEO research and technology development that go all the way back to the Mercury program through Gemini, Apollo, Skylab, the Space Shuttle, and the ISS.

Regardless of what happens next in this transition, NASA will maintain U.S. leadership in LEO and human spaceflight through lunar exploration as a basis for gaining the knowledge and capabilities for Mars consistent with the *ISS Transition Principles*. Within that context, NASA is planning to continue with the following LEO needs and objectives beyond the life of ISS:

- Maintaining the current ISS international partnership and possibly adding new international and domestic participants;
- Conducting regular LEO crewed operations, including short- and long- duration missions:
  - Enabling operational space proficiency;
  - Shifting from human health and performance countermeasures development (the ISS portion of which is expected to be complete by 2024) to validations of integrated long-duration systems, habitation, operations, and crew isolation;
- Developing and demonstrating long-term technology/systems (e.g., life support);
- Conducting space life and physical sciences basic and applied research at current level and capabilities;
- Conducting National-Laboratory-based research and technology development; and
- Providing opportunities for astrophysics, space, and Earth science research.

These long-term requirements, while similar to that of the current ISS Program, could be met with various types of modules or platforms that do not necessitate a vehicle (or vehicles) as complex as the ISS. Many of the research activities could be conducted on shorter-duration platforms, similar to the Space Shuttle, or even crew-tended platforms.

*Fast Forwarding to the Mid-2020s*

Continuing with current policies, including the Commercial LEO Development program, NASA can project what the LEO landscape may look like in the mid-2020s. We will maintain our strong global leadership position in LEO, starting with the continuation of the ISS through 2024, the validation of commercial cargo and crew transportation costs, and the completion of many NASA exploration-related human and systems research and demonstration activities. Through the commercial LEO development program, we hope to have in operation multiple alternatives to the current model of space station operations that can both meet growing commercial needs and meet Government needs at a lower total cost to the Government than exists today.

**Conclusion**

NASA looks forward to working with Congressional stakeholders, researchers, private industry, and our ISS international partners on the future of the ISS and LEO, to ensure that the U.S. maintains our human spaceflight leadership.

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