

Statement of

William H. Gerstenmaier
Associate Administrator for Human Exploration and Operations
National Aeronautics and Space Administration

before the

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

Chairwoman Horn 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 will send the first woman and the next man to the South Pole of the Moon by 2024 and develop a sustainable human presence on the Moon by 2028. We have designated this program "Artemis" – Apollo's twin sister and goddess of the Moon in Greek mythology.

NASA's Artemis program will build a sustainable, open architecture that returns humanity to our nearest neighbor. We are building for the long term, and this time are going to the Moon to stay. We are designing an open, durable, reusable architecture that will support deep space exploration for decades to come. Sustainability requires reusable systems and partnerships from across the commercial sector and around the world.

The Agency is incentivizing speed and drawing on commercial and international partners as it looks to land humans on the Moon within five years. NASA is completing development of both the Orion spacecraft that will carry humans to lunar orbit, and the Space Launch System (SLS) rocket that will launch Orion. We are pressing forward toward the Artemis 1 mission, an uncrewed test flight of Orion and SLS as an integrated system around the Moon. This will be followed by the Artemis 2 mission that will be the first test flight with human crew to the lunar vicinity aboard SLS and Orion. Then, the Artemis 3 mission will send the first crew to the lunar surface.

Critical to this sustainable strategy are the Gateway, an outpost that will orbit the Moon and support missions to the lunar surface, commercial human lander services, and reusable infrastructure on the lunar surface. Artemis 3 will utilize on the Gateway and use commercial human landing services that depart from this outpost. On May 23, 2019, NASA awarded a contract for the first element of the Gateway, the power and propulsion element (PPE). The PPE will use solar-electric propulsion to give us access to more of the lunar surface than ever before. On May 16, 2019, NASA announced the selection of 11 companies to conduct studies and produce prototypes of human landers for its Artemis lunar exploration program. These studies and prototypes will provide critical data needed to inform requirements for the Artemis 3 hardware.

As the Artemis program develops this sustainable deep space exploration architecture, we will continue to draw on ISS capabilities to develop the knowledge and technology required to support missions to the Moon and ultimately to Mars. ISS is supporting development of more efficient life support systems, approaches to managing the health risks of deep space travel, and enhanced understanding of other critical systems for human spaceflight. At the same time, the transition to a vibrant, sustainable LEO economy has the potential to make increasing contributions to exploration by engaging the broader economy.

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. The ISS partnership has developed interoperability standards for human spaceflight that the rest of the world will follow as human presence is expanded into the solar system. ISS has accomplished many things that were never envisioned, such as helping to establish a cube satellite market and creating a market for commercial cargo resupply services that helped underpin the return of commercial satellite launches to the U.S. through reduced launch costs. NASA and the U.S. recognize the huge investments that have been made in ISS and are needed to continue operating it and are looking new ways to leverage the ISS in order to continue U.S. leadership in LEO; we are transitioning NASA's LEO activities to a model where the Agency 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 with U.S. industry in ensuring American preeminence as the world's leading spacefaring nation. We will continue to transition from a Government-led presence in LEO to a private sector model where the Government is one of many users. The ISS has been and will continue to be a key enabler for that new dynamic enterprise.

NASA seeks to achieve a continuous U.S. human presence in LEO – both with Government astronauts and with private citizens – in order to support the utilization of space by U.S. citizens, companies, academia, and international partners, and to maintain a permanent American foothold on the nearest part of the space frontier.

Principles for Transitioning LEO

Several key principles are reflected in NASA's strategy 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 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.

NASA's vision for LEO is a sustained U.S. commercial human spaceflight marketplace with multiple privately-owned/operated platforms – human-tended, permanently-crewed, and/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. The path to these future platforms may either initially leverage ISS or be free-flying, or potentially both. 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.

A robust and competitive LEO economy is vital to continued progress in space. The United States is committed to encouraging and facilitating the growth of the U.S. commercial space sector that supports U.S. needs, is globally competitive, and advances U.S. leadership in the next generation of new markets and innovation-driven entrepreneurship. NASA has developed a long-term plan to achieve this goal where NASA will become one of many customers in LEO. This plan builds on, uses the capabilities of, and applies the lessons learned from over a decade of work and experience with commercial companies.

In the future, NASA will be able to share the cost of LEO platforms and commercial transportation with other commercial, Government, and international users. Allowing the Agency to maximize its resources toward missions beyond LEO, while still utilizing LEO for research, training, and technology development.

For nearly two decades, NASA has been moving from the purchase of hardware and vehicles to purchasing services to support the government's needs in LEO. Initially, NASA experimented with the purchase of non-essential services for ISS, such as the acquisition of water production capabilities through United Technologies Corporation. NASA moved on to stimulate the development of critical cargo delivery systems through the Commercial Orbital Transportation Services Program, which led to the development and purchase of commercial capabilities to provide Commercial Resupply Services for the ISS. This highly successful program resulted in the development of two U.S. cargo delivery capabilities which have delivered over 70 tons of cargo to ISS over the past seven years, and a third system is in development. This partnership changed the way NASA does business and strengthened the American commercial space industry while restoring America's capability to deliver and return ISS cargo.

NASA's Commercial Crew Program (CCP) was formed to facilitate the development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable, and cost-effective access to and from the ISS and LEO. CCP has invested in American companies that are designing and developing these transportation capabilities, and will soon be launching astronauts to the ISS for the first time from U.S. soil since the end of the Space Shuttle Program.

NASA has applied this approach not only to commercial space transportation, but also to purchasing research capabilities as they became commercially available from companies with their own hardware on the ISS. There are currently 14 commercial facilities on the ISS developed by 11 U.S. companies. These research capabilities provide NASA a cost-effective means to expand the research pipeline at reduced costs, without needing to develop new facilities and capabilities in house. Additional companies are working to develop more new hardware and state-of-the-art research capabilities.

NASA is preparing to secure the Nation's long-term presence in LEO by partnering with industry to continue developing commercial enterprises and capabilities that will stimulate and utilize private demand while supporting NASA's long-term needs in LEO. To enable this future, building on the progress made over the last two decades, NASA has developed and is now implementing a Plan for Commercial LEO Development.

NASA's Plan for Commercial LEO Development

NASA is undertaking the Commercial LEO Development program as a focused effort to enable and foster a commercial space economy in LEO. This effort is intended to stimulate both the supply side of the economy – the development of commercially-owned and -operated LEO destinations from which NASA can purchase services, as well as the demand side of the economy – the continued growth of commercial activities in LEO such that NASA is but one of many users purchasing those services.

NASA entered into agreements with 12 industry partners in FY 2018 to study the commercialization of LEO and to gain better insight and help inform recommendations for how the program will move forward with both policy and acquisition efforts. These studies were designed to solicit industry's commercialization concepts, business plans and viability for habitable platforms in LEO, whether using ISS or free-flying, that would enable a commercial marketplace in LEO. The studies also sought to understand the role of Government and the evolution of ISS in the roadmap to the commercialization of LEO, including how private demand for commercial LEO services could be stimulated in order to sustain a long-term LEO marketplace with primarily non-NASA commercial revenue. Insights from the studies were very helpful in refining NASA's plan for commercial LEO development.

NASA publicly released its five-part plan for Commercial LEO Development during a press event at NASDAQ in New York on June 7, 2019, to communicate the exciting potential of the new LEO economy to new and non-traditional entrants.

The plan includes five near-term activities, detailed below:

- 1) Establish ISS commercial use and pricing policy;
- 2) Enable private astronaut missions to ISS;
- 3) Initiate a process for commercial development of LEO destinations;
- 4) Seek out and pursue opportunities to stimulate demand;
- 5) Quantify NASA's long-term needs for activities in LEO.

It is important to note that NASA released these activities as a package rather than individually. From the industry studies, we received a variety of ideas. This prompted us to put together a complete package so that companies could understand the breadth of NASA's plans and policies for LEO and tailor their work with a better sense of the overall direction that NASA intends to take. NASA will not be able to ensure success for all of these companies. Some may start and fail. These companies will be forced to be innovative and creative and their success will depend on their own strengths. NASA is attempting to remove enough risk and create opportunities that allow that some companies to be successful. NASA is

also mindful of the need to not compete with private companies for limited markets by providing free or subsidized services that erode their addressable markets.

Establish ISS commercial use and pricing policy. The ISS is a unique orbiting platform that enables researchers from all over the world to put their talents to work on innovative experiments that can only be conducted in the space environment. Having proven its capability as a platform for a broad array of research disciplines as well as technology development, the ISS also provides an opportunity to test new business relationships. This allows an opportunity to shift from a paradigm of Government-owned and – operated equipment provided by contractors to commercially provided goods and services, with Government as a customer.

More than 50 companies already are conducting commercial research and development on the space station and their results are yielding great promise. This builds on the 14 commercial facilities already supporting research and development (R&D) on ISS. To go beyond R&D and open new opportunities in areas such as manufacturing, marketing and tourism, NASA needs to expand the scope of allowable activities aboard the ISS.

Therefore, NASA has opened the ISS to expanded commercial and marketing opportunities that will continue the Agency’s efforts to develop a sustainable economy in LEO. This is being done through a *NASA Interim Directive on Use of International Space Station (ISS) for Commercial and Marketing Activities*. The new policy enables commercial manufacturing and production, allows both NASA and private astronauts to conduct new commercial activities aboard the orbiting laboratory, and sets commercial prices for the use of U.S. Government resources in pursuit of commercial and marketing activities aboard the ISS. NASA has set aside five percent of the Agency’s ISS utilization resources to serve commercial and promotional activities – with no impact to the 50 percent allocation to the ISS National Laboratory.

With this new policy, U.S. entities will have the ability to pursue the following:

- Manufacturing, production, transportation, or marketing of commercial resources and goods, including products intended for commercial sale on Earth;
- Inclusion of private astronauts on U.S. Government or commercial missions to the ISS and associated on-orbit activities, including commercial and marketing activities;
- U.S. Government astronauts conducting coordinated and scheduled activities in support of commercial and marketing activities;
- Purchase resources available for use on the ISS for commercial and marketing activities.

U.S. entities may pursue these activities if they meet any of the following: require the unique microgravity environment, have a nexus to the NASA mission, or support the development of a sustainable LEO economy.

NASA has also developed a pricing policy that will be updated approximately every six months. This allows industry to understand the cost of obtaining services from NASA. Just establishing prices has created an awareness within NASA of the impact of price on corporate strategy. Learning how the Agency can more effectively incentivize development of a LEO economy will be critical to the successful transition to the private sector.

Enable private astronaut missions to ISS. Building a robust economy in LEO will depend on routine and affordable access to space for humans and cargo. NASA has partnered with Boeing and SpaceX through the Commercial Crew Program to develop the U.S. capability for human access to space.

NASA's accommodation of private astronaut missions to the ISS enables an expanded market opportunity for these commercial service providers. Such missions also expand the scope and amount of commercial activities that private astronauts can accomplish while their missions are at the ISS. The first private astronaut mission, using the U.S.-developed spacecraft, could come as early as 2020.

Market studies identified private astronaut missions to ISS as a key element to demonstrate demand and reduce risk for future commercial destinations in LEO. NASA can accommodate up to two short-duration private astronaut missions per year to the ISS, if supported by the market.

The commercial entity developing the mission will determine the crew composition and ensure private astronauts meet NASA's medical standards, training, and certification procedures to be a member of the ISS crew. A private astronaut assigned to a mission on the space station will have the ability to fulfill duties that fall into the approved commercial and marketing activities outlined in the new commercial use policy.

Initiate a process for commercial development of LEO destinations. In order to meet its long-term research and technology development needs in LEO in a cost-effective manner, NASA must enable the development of a robust commercial human spaceflight economy and facilitate new markets in order to be one of many customers of a broad portfolio of commercial products and services. To enable industry to catalyze new markets, NASA will partner with U.S. industry for the development of commercial destinations in LEO, either using the ISS or by going directly to a free-flying platform.

NASA is offering commercial use of the ISS Node 2 (Harmony) forward port and associated ISS services to enable development, launch, and operations of one or more commercial destination elements. On June 21, 2019, NASA released Appendix I to the Next Space Technologies for Exploration Partnerships (NextSTEP-2) Broad Agency Announcement (BAA) to request proposals from U.S. commercial entities to enter into a public-private partnership with NASA. The goal is to develop commercial markets in one or more habitable commercial elements attached to the space station. Successful ventures will leverage the capabilities of the ISS to stimulate demand and catalyze new markets, leading to a transition to a long-term, sustainable, commercial, human spaceflight enterprise in LEO where NASA is one of many customers. NASA seeks commercial destinations that provide a diverse portfolio of products and services that meet both NASA and non-NASA needs, but do not rely heavily on continued NASA purchase of services in the long term.

In July, NASA plans to release a synopsis for Appendix K to the NextSTEP-2 BAA to enable additional partnerships for development and spaceflight demonstrations of free-flying commercial destinations in LEO. NASA intends to acquire services from the commercial destinations that are produced through Appendix I and K partnerships through a future competitive solicitation. NASA expects that it will remain a major customer of commercial space stations until the Agency's goal of being one of many customers is realized.

Seek out and pursue opportunities to stimulate demand. If NASA is to achieve its goal of becoming one of many customers of future commercial destinations in a robust LEO economy, the Agency must partner with industry to catalyze and nurture the development of sustainable, scalable, and profitable non-NASA demand for services in LEO. NASA is taking a multi-pronged approach, including using NASA Research Announcements (NRA) and the NextSTEP-2 BAA.

NASA has expanded the ISS Utilization NRA to request proposals from U.S. industry for commercial concepts with a focus on the areas of in-space manufacturing and regenerative medicine/bioengineering, and will also consider other fields that may lead to a scalable, financially self-sustaining demand for LEO capabilities. Successful ventures will further mature concepts with potential for scalability, such as

returning high-value items for terrestrial use, capturing sizeable markets or creating new markets, and disrupting existing technologies by taking advantage of the ISS, and eventually follow-on human-rated destinations in LEO.

NASA has released Appendix J to the NextSTEP-2 BAA to request proposals from U.S. entities. NASA seeks proposals that, if successful, will: strengthen NASA's insights into opportunities for reducing cost and technical barriers to enable space market growth; identify actionable recommendations, and lead to a strong LEO economy with NASA as one of many customers of commercial transportation and destinations in LEO.

Quantify NASA's long-term needs for activities in LEO. On October 26, 2018, NASA released the white paper *Forecasting Future NASA Demand in Low-Earth Orbit*. It provided a qualitative description forecasting the types of research- and exploration-related activities NASA will conduct in the future in LEO. As the fifth part of NASA's Plan for Commercial LEO Development, the Agency has updated this white paper to include a quantification of the demand forecast, representing the type and amount of services that NASA intends to purchase in the future when those services become available on one or more commercial destinations. NASA is planning to continue with the following LEO needs and objectives beyond the life of ISS:

- Maintaining the ISS international partnership and developing new relationships with other 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 those 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 crew-tended platforms.

Commercial LEO Development will advance the Nation's goals in LEO and exploration by furthering the development and maturity of the commercial space market. This will enable private industry to assume roles that have been traditionally Government-only, by creating new opportunities for economic growth through new markets and industries in LEO, and potentially yielding long-term cost savings to the Government by leveraging private industry innovation and commercial market incentives.

Future of the ISS Platform

In recent years, the space station's retirement date has become a very important topic of discussion. Although it is likely technically feasible to continue to operate the ISS in the short term with continued maintenance, there is a very real potential that critical systems could fail or the ISS could suffer a major damaging impact from orbital debris, bringing the lifetime of the facility to an end. New commercial

systems or approaches to managing the ISS could potentially significantly reduce the costs of operating in LEO. These approaches will need to look at creative ways to lower transportation costs, but they will ultimately make ending direct Government funding for ISS possible. The Administration has challenged NASA to accomplish this goal by 2025 and we are seeking to do so. We recognize the numerous difficulties inherent in this challenge, but also the importance of starting along this path. In all circumstances, NASA is committed that there will be no gap of a U.S. human presence in LEO. As the private sector develops capability, ISS use will need to be moderated to not compete with the private sector. This transition will be challenging and require close Government and private sector interaction. The LEO economy will not reach its full potential if the Federal Government is the sole supplier of, or demand for, LEO research capabilities. One key will be the private sector creating demand beyond the needs of the U.S. Government.

The future of the ISS platform will be evaluated using the *ISS Transition Principles* previously described, to ensure there is no gap in the availability of a LEO destination to meet NASA's needs. NASA will pursue an orderly transition to new commercial destinations in LEO as they become available and demonstrate their capabilities and ability to meet NASA's needs. We will continue to discuss decisions about the future of the ISS across the ISS international partnership.

Conclusion

NASA will continue its mission in LEO with the ISS to enable exploration, while performing research that benefits humanity, supporting National Laboratory research by private industry and other organizations, and working towards reducing operations and maintenance costs. The Agency will create new opportunities for collaboration with industry on the ISS and develop public-private partnerships for exploration systems that will extend human presence into the solar system. NASA is working to leverage commercially-provided services that help enable deep space exploration and private sector expansion in LEO. These services will continue and accelerate the transition of human spaceflight operations in LEO to commercial partners in support of NASA and non-NASA needs. To support this transition, NASA will focus on partnerships with commercial industry to develop future commercial destinations and stimulate growth of demand for services from those destinations, as well as meeting Government requirements in LEO.

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 its human spaceflight leadership.

WILLIAM H. GERSTENMAIER
ASSOCIATE ADMINISTRATOR FOR
HUMAN EXPLORATION AND OPERATIONS

William H. Gerstenmaier is the associate administrator for the Human Exploration and Operations Mission Directorate at NASA Headquarters in Washington, DC. In this position, Mr. Gerstenmaier provides strategic direction for all aspects of NASA's human exploration of space and cross-agency space support functions of space communications and space launch vehicles. He provides programmatic direction for the continued operation and utilization of the International Space Station, development of the Space Launch System and Orion spacecraft, and is providing strategic guidance and direction for the commercial crew and cargo programs that will provide logistics and crew transportation for the International Space Station.



Mr. Gerstenmaier began his NASA career in 1977 at the then Lewis Research Center in Cleveland, Ohio, performing aeronautical research. He was involved with the wind tunnel tests that were used to develop the calibration curves for the air data probes used during entry on the Space Shuttle.

Beginning in 1988, Mr. Gerstenmaier headed the Orbital Maneuvering Vehicle (OMV) Operations Office, Systems Division at the Johnson Space Center. He was responsible for all aspects of OMV operations at Johnson, including development of a ground control center and training facility for OMV, operations support to vehicle development, and personnel and procedures development to support OMV operations. Subsequently he headed the Space Shuttle/Space Station Freedom Assembly Operations Office, Operations Division. He was responsible for resolving technical assembly issues and developing assembly strategies.

Mr. Gerstenmaier also served as Shuttle/Mir Program operations manager. In this role, he was the primary interface to the Russian Space Agency for operational issues, negotiating all protocols used in support of operations during the Shuttle/Mir missions. In addition, he supported NASA 2 operations in Russia, from January through September 1996 including responsibility for daily activities, as well as the health and safety of the NASA crewmember on space station Mir. He scheduled science activities, public affairs activities, monitored Mir systems, and communicated with the NASA astronaut on Mir.

In 1998, Mr. Gerstenmaier was named manager, Space Shuttle Program Integration, responsible for the overall management, integration, and operations of the Space Shuttle Program. This included development and operations of all Space Shuttle elements, including the orbiter, external tank, solid rocket boosters, and Space Shuttle main engines, as well as the facilities required to support ground processing and flight operations.

In December 2000, Mr. Gerstenmaier was named deputy manager, International Space Station Program and two years later became manager. He was responsible for the day-to-day management, development, integration, and operation of the International Space Station. This included the design, manufacture, testing, and delivery of complex space flight hardware and software, and for its integration with the elements from the International Partners into a fully functional and operating International Space Station.

Named associate administrator for the Space Operations Mission Directorate in 2005, Mr. Gerstenmaier directed the safe completion of the last 21 Space Shuttle missions that witnessed assembly complete of the International Space Station. During this time, he provided programmatic direction for the integration and operation of the International Space Station, space communications, and space launch vehicles.

In 2011, Mr. Gerstenmaier was named to his current position as associate administrator for the Human Exploration and Operations Mission Directorate.

Mr. Gerstenmaier received a bachelor of science in aeronautical engineering from Purdue University in 1977 and a master of science degree in mechanical engineering from the University of Toledo in 1981. In 1992 and 1993, he completed course work for a doctorate in dynamics and control with emphasis in propulsion at Purdue University.

Mr. Gerstenmaier is the recipient of numerous awards, including three NASA Certificates of Commendation, two NASA Exceptional Service Medals, a Senior NASA Outstanding Leadership Medal, the Meritorious Executive Presidential Rank Award, and Distinguished Executive Presidential Rank Award. He also was honored with an Outstanding Aerospace Engineer Award from Purdue University. Additionally, he was twice honored by Aviation Week and Space Technology for outstanding achievement in the field of space. His other awards include: the AIAA International Cooperation Award; the National Space Club Astronautics Engineer Award; National Space Club Von Braun Award; the Federation of Galaxy Explorers Space Leadership Award; AIAA International Award; the AIAA Fellow; Purdue University Distinguished Alumni Award; and honored at Purdue as an Old Master in the Old Masters Program; recipient of the Rotary National Award for Space Achievement's National Space Trophy; Space Transportation Leadership Award; the AIAA von Braun Award for Excellence in Space Program Management; and the AIAA von Karman Lectureship in Astronautics.

He is married to the former Marsha Ann Johnson. They have two children.

October 2015