HOLD FOR RELEASE
UNTIL PRESENTED
BY WITNESS
September 26, 2018

Statement of

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

before the

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

Mr. Chairman and Members of the Subcommittee, I am very pleased to appear before you today. NASA is proud to be at the forefront of a global effort to advance humanity's future in space, leading the world while expanding on our Nation's great capacity for exploration and innovation. This is a role the Agency has played for 60 years, leveraging the talent and hard work of America's skilled Government and aerospace industry workforce to push the boundaries of science, exploration, and technology development to achieve bold goals in the aviation and space arenas. Now, pursuant to Space Policy Directive-1 (and consistent with the NASA Transition Authorization Act of 2017), NASA is pursuing "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." We are working on a sustainable campaign of exploration, transitioning the International Space Station (ISS), returning humans to the surface of the Moon and lunar orbit, where we will build the systems, deep space infrastructure, and operational capabilities to expand human presence beyond the Earth-Moon system, eventually embarking on human missions to Mars and other destinations.

The Past Is Prelude

From its earliest days, NASA has pushed the envelope in human spaceflight, with the 1960s dominated by the Agency's efforts to land a man on the Moon and return him safely to the Earth before the end of the decade. The Apollo program sent nine crews around the Moon, with six of those conducting landings on the lunar surface. The 1970s saw Skylab, America's first space station, the Apollo-Soyuz mission, and the development of the remarkably capable Space Shuttle. From 1981 to 2011, NASA launched 135 Space Shuttle missions, with crews conducting an array of research, repairing and extending the operational life of the Hubble Space Telescope, deploying space probes, delivering satellites, conducting docked missions with the Russian Mir space station, and playing a key role in building and supplying the ISS. In the 1990s, NASA worked with its international partners on the ISS, the first element of which was launched in November 1998. By the advent of the first expedition to ISS in November 2000, a new era of international collaboration in LEO had begun. With the retirement of the Space Shuttle in 2011, NASA relied on U.S. commercial providers for cargo transportation, and soon, Americans will be flying to and from ISS aboard vehicles owned and operated by U.S. industry – a very different paradigm from the framework used previously. ISS represents the current pinnacle of human spaceflight, building on NASA's 60-year history of achievement, yet it is also the starting point for an Exploration Campaign that will carry humanity out into the solar system.

Exploration Campaign

The National Space Exploration Campaign builds on 18 years of Americans and our international partners living and working continuously on the ISS. It leverages the advances made in commercial launch vehicle capabilities, robotics, and other technologies, and accelerates in the next few years with the launch of the Orion capsule and Space Launch System (SLS) rocket which will expand human exploration to cislunar space and the surface of the Moon.

A key component of establishing the first permanent, American presence and infrastructure on and around the Moon is the Gateway, a spacecraft assembled in cislunar space that will be used as a staging point for missions to the lunar surface and to deep space destinations. The Gateway will not be continuously occupied like the ISS. NASA currently envisions crew visits approximately once per year, so a strong focus is placed on robotic activities and infrastructure to foster ongoing investigations and operations that can operate autonomously between crew visits. Gateway in-space assembly starts with the launch of the power and propulsion element (PPE) no later than 2022 aboard a commercial rocket. Gateway ground testing, risk reduction, and development activities are already underway at NASA centers across the United States, including facilities in Ohio, Texas, Florida, Virginia, and Alabama, as well as in facilities of private sector partners in those states as well as in Colorado and Nevada. Following the successful in-space demonstration of the PPE and the delivery of the first pressurized Gateway modules, U.S. astronauts will be visiting before the end of 2024.

As part of the Campaign, we will also begin sending increasingly capable robotic missions to the lunar surface in the next two years. Developed by U.S. commercial companies, these spacecraft will conduct scientific investigations, characterize resources, and provide lunar landing services to customers from America and around the world. Ultimately, these efforts will culminate in the safe landing of U.S. astronauts on the Moon before the end of the 2020s.

We will also continue to execute sophisticated robotic missions to Mars while we work to develop and demonstrate the deep space capabilities required to safely send a human crew to the Red Planet.

Activities across these domains are closely related and mutually supportive; for example, NASA's drive to conduct robotic and human exploration of the Moon informs the research and technology development we will conduct on the ISS and potential future orbital platforms, as well as the development of technologies needed for future Mars missions. Likewise, current and future robotic missions will provide vital science, reconnaissance, and technology demonstrations in support of future human exploration, in addition to their science objectives. NASA is actively working now to support sustainable exploration and development over the coming decades in all three domains.

The Exploration Campaign has five strategic goals:

1. Transition U.S. human spaceflight in LEO to commercial operations that support NASA and the needs of an emerging private sector market.

2. Lead the emplacement of capabilities that support lunar surface operations and facilitate missions beyond cislunar space.

3. Foster scientific discovery and characterization of lunar resources through a series of robotic missions.

4. Return U.S. astronauts to the surface of the Moon for a sustained campaign of exploration and utilization.

5. Demonstrate the capabilities required for human missions to Mars and other destinations.

NASA will act as architect, mission leader, and in several key areas, systems integrator, defining an open architecture that meets National objectives. The Exploration Campaign will draw upon a variety of innovative partnerships with U.S. commercial industry, other Government agencies, academia, and international partners. We have designed the Exploration Campaign to enable early successes, relying on seamless collaboration across the Agency, including Deep Space Exploration Systems, Exploration Technology, LEO and Spaceflight Operations, and elements of Science, and the rapidly advancing capabilities of our commercial partners. I'll now describe our plans in each major domain of the Campaign – Earth Orbit, the Moon, and Mars – in more detail.

Transitioning LEO

The ISS will continue to serve as a core long-duration human spaceflight asset through at least 2024 – which will mark nearly 25 years of continuous human occupancy. Currently, NASA is leveraging the ISS to learn how to keep crews healthy and productive on deep space missions, and as a testbed to develop technologies to support those missions. The ISS is an experiential testing ground that enables discovery and development of advanced robotics, communications, medicine, agriculture, and environmental science. ISS also provides an example of international collaboration on large space projects. ISS can also enable the transition to commercial companies' use of LEO. NASA recently awarded 12 study contracts to industry to investigate the best way to use the ISS to enable commercial industry to take a lead role in LEO. The portfolio of selected studies will include specific industry concepts detailing business plans and the viability of habitable platforms, using Station or separate free-flying structures.

Maintaining the ISS and future orbital platforms requires a fleet of vehicles to sustain a constant supply line of both crew and cargo. Under the original Commercial Resupply Services (CRS) contracts, our two commercial cargo partners, Space Exploration Technologies (SpaceX) and Orbital ATK (now Northrop Grumman), are providing cargo deliveries to the ISS. Under the new CRS-2 contracts, SpaceX, Northrop Grumman, and Sierra Nevada Corporation will deliver critical science, research, and technology demonstrations to the ISS over five years from 2020 through 2024. Working with our commercial crew partners, SpaceX and the Boeing Company, NASA plans to return crew launch capability to American soil in 2019.

Under the auspices of the ISS National Laboratory, managed by the Center for the Advancement of Science In Space (CASIS), NASA and CASIS continue to expand research on the ISS sponsored by pharmaceutical, technology, consumer product, and other industries, as well as by other Government agencies, such as the National Institutes of Health and the National Science Foundation. Through CASIS' efforts, the ISS National Lab has reached full capacity for allocated crew time and upmass and downmass. NASA also works with commercial companies, such as NanoRacks, to support commercial activity on the ISS.

NASA intends to transition from the current Government-dominated model of human space activities in LEO to a model where Government is only one customer for commercial services. Starting in 2018, the Agency will increase the breadth and depth of commercial and international LEO activities. NASA will expand partnerships in LEO to include new companies and new nations, including working with commercial partners to support new international astronaut visits. Based on inputs from current ISS partners, commercial and other stakeholders, NASA will shape the plan for the transition of LEO activities from direct Government funding to commercial services and partnerships, with new,

independent commercial platforms or a non-NASA operating model for some form or elements of the ISS by 2025. In addition, NASA will expand public-private partnerships to develop and demonstrate technologies and capabilities to enable new commercial space products and services.

Lunar Exploration

NASA is building a launch and crew system – the Orion spacecraft, the heavy-lift SLS launch vehicle, and the supporting Exploration Ground Systems (EGS) – to support the Exploration Campaign. The Orion crew vehicle will carry up to four humans to deep space for up to 21 days. The Orion will also be able to transport and dock co-manifested modules to Gateway, and provide key initial life-support and abort capabilities. The SLS Block 1 cargo variant will be capable of delivering Orion to cislunar space in the early 2020s, and the Block 1B SLS will be capable of delivering 8-10 metric tons co-manifested with Orion in the mid- to late-2020s. The first SLS/Orion mission will be the uncrewed Exploration Mission-1 (EM-1), to be launched to lunar orbit in FY 2020, followed by the first crewed SLS/Orion mission, EM-2, no later than 2023. These SLS/Orion missions will demonstrate the capability to operate safely and productively around the Moon. These are the early steps on a journey that leads American astronauts into deep space, sustainably and permanently.

SLS Core Stage integration and outfitting (including installation of the four RS-25 main engines developed from the Space Shuttle) has continued at Michoud Assembly Facility. EM-1 flight hardware is being delivered to the Kennedy Space Center (KSC). SLS has continued a series of EM-1 Design Certification Reviews, will conduct the Critical Design Review (CDR) for EM-2, and begin fabrication of components for EM-3 and beyond. For EM-1, the Orion European Service Module is scheduled to be delivered soon to the Operations and Checkout Building at KSC for integration with the Crew Module. NASA is accelerating the Ascent Abort-2 test (AA-2) into 2019, ahead of EM-1. Structural work is already underway on Orion EM-2 flight hardware production. Orion has continued qualification testing of systems for EM-2. This year, EGS will complete the system verification and validation phase and begin the operations and integration phase in preparation for multi-element verification and validation for the Mobile Launcher, Pad, and Vehicle Assembly Building.

NASA will also begin to build the in-space infrastructure for long-term exploration and development of the Moon by delivering to lunar orbit a power and propulsion element (PPE), planned to be launched in 2022 on a commercial rocket, as the foundation of the Gateway. NASA released the PPE final Broad Agency Announcement (BAA) in September and proposals are due in November. This BAA is designed to leverage the commercial communication industry's extensive experience in building and operating spacecraft. The Gateway is envisioned to be a spacecraft operating in the vicinity of the Moon that demonstrates crewed and uncrewed operations in deep space. It will be incrementally built in place using SLS, the Orion crew vehicle, and commercial launch vehicles. The Gateway will be assembled in lunar orbit where it can be used as a staging point for missions to the lunar surface and destinations in deep space, providing a flexible human exploration architecture depending on mission needs. Although there are various concepts for its configuration, current analysis suggests the initial functionality will include four main capabilities: PPE; habitation; airlock to enable science and EVA; and logistics for cargo delivery, science utilization, exploration technology demonstrations, and potential commercial utilization. With the initial habitation capabilities delivered to cislunar space, crews of four – launched on Orion – will visit the Gateway on missions initially lasting 30 days and up to 90 days as new modules are added to complete Gateway's full capabilities.

Gateway will enable system and operational demonstrations, scientific exploration, biological and biomedical science, and will serve as an eventual aggregation and departure point for crewed missions to the lunar surface and other deep space destinations. The Gateway will serve as a critical platform to conduct biological and biomedical studies that require a beyond-LEO space environment to study the

response of biology (human and non-human organisms) to this new environment. A key science-enabling feature of this spacecraft is exposure of organisms to the deep space radiation environment for radiation and combined radiation/microgravity studies. The Gateway will also serve as a platform to mature necessary short- and long-duration deep space exploration capabilities in the 2020s, including highly reliable and dormancy-tolerant environmental control and life support systems; logistics reduction capabilities; advanced in-space propulsion; automated rendezvous and docking; radiation monitoring and mitigation capabilities; and integrated human-robotic mission operations, to name a few.

NASA has established the Lunar Discovery and Exploration Program (LDEP) in the Science Mission Directorate and is leveraging the Agency's extensive lunar science experience and data for lunar exploration. We are jump-starting commercial partnerships, innovative approaches for building and launching sophisticated next-generation science instruments, and the development of small rovers that will reach the Moon's surface via commercial landers. The Agency is integrating science and human exploration goals, including the eventual return of humans to the Moon. Just this past year, scientists used data from NASA's Lunar Reconnaissance Orbiter to identify areas in lunar craters that are cold enough to have frost present on the surface – ice that could provide crucial resources for exploration while also containing valuable information about the chemical makeup of the early solar system.

NASA is supporting the development of commercial lunar exploration capabilities leading to a human lunar landing. The Advanced Cislunar and Surface Capabilities (ACSC) program in the Human Exploration and Operations Mission Directorate will focus on engaging U.S. industry partners using innovative approaches to combine lunar robotics, a cislunar presence, and lunar landing capabilities building up to a human-rated lander. In 2019, ACSC and LDEP will support initial risk reduction activities by incorporating results from the following.

- The Lunar Cargo Transportation and Landing by Soft Touchdown (CATALYST) initiative is encouraging the development of U.S. private-sector robotic lunar landers capable of successfully delivering payloads to the lunar surface using U.S. commercial launch capabilities.

- NASA issued a request for proposals (RFP) for Commercial Lunar Payload Services (CLPS) on September 6, 2018, encouraging the U.S. commercial space industry to introduce new technologies to deliver payloads to the Moon. NASA intends to award multiple contracts for these services through the next decade, with contract missions to the lunar surface expected to begin as early as 2019, and with a company's first delivery no later than Dec. 31, 2021.

- NASA is also working on the second phase of the Next Space Technologies for Exploration Partnerships (NextSTEP), an effort to stimulate deep-space capability development across the aerospace industry. Through NextSTEP, the Agency intends to seek proposals from industry in support of design analysis, technology maturation, system development and integration, and spaceflight demonstrations for human-class lunar landers. This will address the development of medium- to large-scale lunar lander capabilities that have extensibility to reusable, human-class landers to a wide range of destinations on the lunar surface.

Ultimately, the Moon will also serve as a stepping-stone, a training ground, and a platform to strengthen commercial and international partnerships and prepare for future human missions to Mars and other destinations.

NASA will advance robotic access to Mars in preparation for human exploration. The Agency will:

- Continue the search for life with a Mars rover in 2020;

- Demonstrate technology to produce oxygen from Mars resources, critical for future human Mars missions;
- Begin planning a first-ever sample-return Mars mission;
- Prioritize and guide investments and partnerships in long-pole technology areas and resource characterization needed for deep-space exploration; and
- Develop standards for human long-duration deep space transportation vehicles.

Exploration Technology

Critical to the Exploration Campaign, NASA will conduct research and promote technology development to address needs for human and robotic space exploration and to foster commercial expansion in LEO, cislunar space, and beyond. NASA's Technology research drives exploration by spanning the Technology Readiness Level spectrum, including investments in early-stage concepts and prototypes. Exploration Research and Technology key areas of focus will include:

- Advanced environmental control and life support systems;
- In-Situ Resource Utilization (ISRU);
- Nuclear and solar power and propulsion technologies for exploration;
- Advanced communications, navigation, and avionics;
- In-space manufacturing and on-orbit assembly;
- Advanced materials;
- Entry, Descent, and Landing;
- Autonomous operations; and
- Research to enable humans to safely and effectively operate in various space environments.

NASA continues to partner with researchers across academia, industry, and within the Agency to explore transformative technologies and approaches. Upcoming early-stage innovation activities will investigate areas such as breakthrough propulsion, challenges in deep space human habitation, space-optimized energy systems, radiation protection, and materials. These areas are part of a comprehensive approach to efficiently support innovative discovery, progress toward important goals, and development of exciting new capabilities.

In August, NASA selected 10 proposals from six U.S. companies, with a combined award value of approximately $44 million, to develop commercial space capabilities that benefit future NASA exploration missions in new public-private partnerships, including lunar lander and deep space rocket engine technologies. While these "Tipping Point' partnership selections will enable NASA's future science and human exploration missions, these awards will also grow the economy and strengthen the Nation's economic competitiveness.

This past spring, NASA also selected 10 companies to conduct studies and advance ISRU technologies to collect, process, and use space-based resources for missions to the Moon and Mars. ISRU could increase safety and affordability of future human spaceflight missions by limiting the need to launch supplies such as oxygen and water from Earth. In the area of Flight Opportunities, suborbital flight providers are now on the verge of a significant leap forward, and payloads are beginning to fly from multiple providers. Given this success, NASA will shift our focus to funding more payload flights. To date, Flight Opportunities has enabled 122 flights of 93 payloads. There are an additional 62 payloads awaiting flight. Later this year, we look forward to the launch of the Green Propellant Infusion Mission and the Deep Space Atomic Clock on the U.S. Air Force's Space Technology Mission-2 on a SpaceX Falcon Heavy booster.

Conclusion

As NASA celebrates its 60th anniversary, one of the Agency's key goals is opening the space frontier with the objective of extending human presence deeper into the solar system starting with returning humans to the Moon through a sustainable human and robotic spaceflight program. The Agency has developed a strategic, pioneering approach to expand the distance and duration of human space exploration, building off the research happening today on the International Space Station. NASA is pushing human presence deeper into space while making new discoveries and strengthening the Nation's diplomatic posture. We appreciate the Subcommittee's continued support, and I would be pleased to respond to your questions.