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Statement of

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Introduction

Mr. Chairman and Members of the Committee, I am pleased to have this opportunity to discuss America's plans for deep space exploration, including sending human missions to Mars. Within my 30 years of experience at NASA, I have watched our exploration goals evolve, becoming now a global effort to advance humanity's presence and continued exploration of space. The future exploration plan is complex and necessarily integrated across commercial and international lines. As it should be. While the idea of expanding our horizons is simple, the actual design solutions and the implementation of a plan, adapting when problems invariably strike, and pressing forward in spite of obstacles is the embodiment of exploration.

Sustainability will be a key in the success of our future exploration as we expand our presence across the solar system. Learning and building from each successive advancement will give us an enduring platform for growth. And though space is the goal, the benefits of the end results will be closer to home, spurring additional commercial activity in low-Earth orbit [LEO] and expanding our knowledge and opportunities here on Earth as we search for and find those necessary innovative solutions. For example, our technologies developed for water purification and recycling on the International Space Station [ISS], a critical component for continued exploration to the Moon and Mars, also have applications on Earth in areas where clean water is limited. A United States led expansion of humans to the Moon via the Gateway will allow for sustainable exploration and scientific utilization, as well as the practical testing of new partial gravity technologies and operations methods that are critical for the subsequent missions to Mars.

NASA's Exploration Campaign addresses the necessity of developing a sustainable approach, pursuing a new lunar exploration program by employing expertise and resources across the Agency and commercial and international partners in support of: a science and technology initiative; a small commercial lander initiative; a development activity for commercial mid-to-large landers to address both science and human exploration objectives; and Gateway. The effort is built to enable early successes, with seamless collaborations.

International Space Station

With three trips to the ISS over the last 16 years, I can personally vouch for its value in the evolution of our space exploration. International and commercial relationships have been built

and forged and continue to expand in ever-changing roles. These partnerships will be critical to future successes in space, as we approach even more difficult problems, further from our home world. Also, on ISS we have incorporated the hard-earned lessons of building, repairing and living in the most complex engineering achievement ever constructed in the vacuum of space. All of these lessons will apply during the establishment of our presence in deep space and on the lunar and Mars surfaces. The ISS also serves as an invaluable platform for testing, redesigning and re-testing technologies that will make our next steps away from the planet sustainable.

For the human part of the equation, we have conducted literally hundreds of experiments during our 18-year presence on board the ISS, specifically expanding our knowledge about the effects of living in space and developing new protocols and mitigations to reduce our risks of being there. Studies ranging from bone loss and exercise mitigations to spaceflight neuro-ocular system changes, nutrition requirements, host-microorganism interactions, and immune response have been completed or are on-going now. Knowledge gained is being incorporated into future vehicle designs and operations protocols that will enable our continued human presence beyond Earth.

As a scientist myself, I am truly excited about the whole range of research that we are able to conduct on board station, including research in engineering and physical sciences, biology, the Earth, and the universe. Soybeans to superconductor crystals, cardiac stem cells and antibody-conjugated cancer drug therapies, and fuel combustion experiments is just a tiny list of some of the space research in which I personally participated. 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. I anticipate that this research will grow into a commercial industry as more and more studies demonstrate the value of the ISS as a National Laboratory.

Systems for Exploration

New deep space systems, including the heavy-lift Space Launch System (SLS), Orion crew vehicle, the Exploration Ground Systems (EGS) that support them, commercial launch vehicles, lunar landers, and new deep space habitation capabilities, are being developed by NASA through public-private and international partnerships. Missions planned on SLS in the 2020s will establish the capability to operate safely and productively in deep space.

A key component of the sustainability and flexibility of the plan will include the presence of a Gateway. In addition to a U.S. strategic presence in lunar space, the Gateway will be a place to live, learn and work around the Moon and will provide opportunities to support missions to the surface. Leveraging the knowledge gained in exploring the Moon and utilizing its situ resources will then directly apply toward human missions to Mars. Testing and refining in-space power and propulsion and deep space habitation will also be critical objectives to test and refine for the success of a human presence on Mars.

An Integrated Effort

NASA's Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) lander launched in May, 2018 and will land on Mars in November – joining a series of NASA rovers, landers, and orbiters already at the Red Planet. InSight's advanced payload will provide

unique information on the interior structure of Mars, providing glimpses into the processes that shaped the rocky planets of the inner solar system. The future Mars 2020 rover and planning for a potential Mars Sample Return mission, incorporating commercial and international partnerships, will also provide essential data for human presence in the future.

Lunar Activities and Beyond

As part of the NASA's overall strategy to conduct deep space exploration, the Agency is supporting the development of commercial lunar exploration. A new cross-Agency campaign will combine science and exploration objectives in Advanced Cislunar and Surface Capabilities. One specific example of this approach is the Lunar Cargo Transportation and Landing by Soft Touchdown (CATALYST) initiative, which encourages 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. As part of the Exploration Campaign, NASA will initiate a series of robotic lunar missions in partnership with industry as early as 2019, eventually leading to a continual human presence on and around the Moon.

NASA also is at work 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 these initial public-private partnerships, NextSTEP will provide advanced concept studies, technology development projects, and significant measurements in key areas, including habitat concepts, environmental control and life support systems, advanced in-space propulsion, and small spacecraft to conduct missions related to strategic knowledge gaps. NASA is already integrating ground testing of habitation capabilities developed by the NextSTEP partners.

Conclusion

In my 665 days in space, I have personally experienced overcoming seemingly impossible obstacles, learning resourcefulness imposed by the unique and harsh environment of space. I have seen some of the best of what human beings have to offer. And been lucky enough to have participated as a member of our world community in striving for each new level of competence, including the advancement of commercial capabilities. I recommend that we take these lessons from Space Station, understanding that it is a microcosm of what will need to happen on much larger scale in our future exploration.

I believe that developing a flexible deep space infrastructure to support a steady cadence of increasingly complex missions will strengthen American leadership in a quest to go where no person has gone before. By leveraging commercial partnerships and international collaborations, we will ensure that the best minds in the universe are working toward our exploration objectives. With NASA's leadership, a logical approach to expand the distance and sustainability of human space exploration will continue, building on the on the ISS, and increasing capabilities with SLS, Orion, and EGS programs. These strategies hold the highest likelihood of success and promise to extend technical and scientific benefits to all of humankind.

Mr. Chairman, I would be pleased to respond to your questions and those of other Members of the Committee.