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Chairman Babin, Ranking Member Edwards, and members of the Committee, on behalf of The Boeing Company, thank you for the opportunity to testify today to provide an update on Boeing's role in the International Space Station (ISS).

Boeing is extremely proud to have supported NASA in the design, integration and assembly of the ISS. As NASA's prime contractor, Boeing delivered the U.S. elements of the ISS and provided system integration and stage-by-stage assembly on orbit of all U.S. and international elements. We continue in the ISS sustainment role today.

On November 2nd the world will celebrate 15 years of continuous human presence in space, with international crews living and working aboard ISS. At a time when many decry a gap in America's space program as we transition from the Space Shuttle to commercial transportation solutions, we who know ISS know that America and our partner nations are making advances in space every day.

Consistent with the Committee's request, I am pleased to share some of these advances as I address current ISS operational capabilities and improvements to maximize ISS utilization, as well as Boeing's role in technical issue resolution in cooperation with NASA and the International Partners.

Current Operational Capabilities.

The International Space Station has been recognized as the largest, most complex international scientific and engineering project in history and the world's largest endeavor in space to date. Ongoing improvements have made ISS even better.

The Station brought together hardware and software from 16 countries, 37 states and more than 10,000 suppliers, often with first-time integration occurring on orbit. About the size of an American football field, the ISS is larger than a six bedroom house and has the internal pressurized volume of a Boeing 747.

An electrical power system with eight miles of wiring receives its power from more than an acre of solar arrays – a surface area that could cover the U.S. House chamber three times. Those same solar arrays make ISS the brightest object in the night sky after the moon. Featuring three dedicated research laboratories – the U.S. Destiny Laboratory, the European Space Agency's Columbus Laboratory, and the Japanese Kibo Laboratory – ISS is the world's preeminent microgravity research facility.

ISS is an engineering marvel, a beacon for international cooperation, and a shining example of what can be achieved through strong leadership and unity of purpose for the benefit of humankind.

As NASA's contractor for sustaining engineering for the ISS, Boeing is responsible for maintaining the station and ensuring the full availability of the unique research laboratory for NASA, International Partners, other U.S. government agencies and private companies.

Operational Efficiencies and Improvements.

Boeing continues to work with NASA to reduce the costs of sustaining the International Space Station. Over the past 10 years, we have reduced the cost of our sustainment role by more than 30 percent.

This savings has enabled NASA to fund ISS improvements such as the NASA Docking System, which includes the International Docking Adapter (IDA) – a critical component supporting the increase in the number of commercial vehicles visiting the Station and enabling NASA and the International Partners to increase the crew size on Station. The crew spends approximately 35 hours a week dedicated to space station science and research. When we increase crew size by one, the research time nearly doubles.

ISS Space to Ground communications channels have been improved, allowing for more real time interaction between crew members performing experiment tasks on-orbit and science experts on the ground. This real-time dialogue enables quick adjustments to research parameters while the experiment is being conducted, providing more meaningful results.

ISS now provides higher quality video downlinks to support more detailed observations and a higher rate data downlink to send more science data to analysts on the ground more quickly. Higher speed data downlinks are particularly important due to the large data sets coming down from ISS.

The ISS power system has been upgraded to 110 VAC. This is important because it allows the use of commercial-off-the-shelf hardware on ISS instead of more expensive custom or highly modified equipment, which can deter prospective researchers. Because 110 VAC is what most ground-based laboratories use, this also allows easy transition of equipment and significantly lowers the cost of laboratory outfitting.

These improvements help to keep ISS operating at peak efficiency today and provide a basis for continuing strong performance well into the future. Boeing recently completed a technical assessment of the useable life of major ISS hardware components. Our study indicates that the Station will be operable to at least 2028. Long-term viability of the Station is an important factor in continuing to attract researchers, who invest considerable time in preparing their experiments for conduct in space.

Maximizing ISS Science and Utilization.

The continuing on-orbit reliability of ISS and the improvements made to further enhance research capabilities are a boon to maximizing facility utilization. Our experiences and investigations on ISS are providing many benefits and improvements both to enable

continuing human space exploration, and also to improve the quality of life here on Earth.

ISS continues to be used for developing multiple technologies for deep space exploration such as critical life support systems and environment monitoring systems. NASA is developing and testing highly reliable life support systems to address needs for future exploration habitation systems. This includes important carbon dioxide removal systems, oxygen generation systems, and the systems needed to monitor and detect things like trace gases, water contaminants and microbes. All of this is critically important to learn on the ISS before we make longer duration missions farther into our solar system, such as future missions to Mars.

To put the distance from the Earth to Mars in perspective, if the Earth were a classroom sized globe, the ISS would be less than a half of an inch from that globe, the Earth's moon would be about 30 feet from the globe, and Mars would be another 10 miles farther away. Testing and learning on the space station – here, close to the resources of home – is proving to be an intelligent early step on the threshold of deeper space exploration.

The ISS is a test bed for learning how the body reacts to prolonged weightlessness, and allows us to develop countermeasures now. We are learning today the effects and extent of bone loss in zero-g. We are also learning the long-term effects on the neuro vestibular system, as well as the impacts to our ocular system.

We are learning self-sustainment skills, such as growing food in space and recycling water. All of these things are important to learn and understand before we explore farther into our solar system.

Research on ISS has led to numerous improvements on Earth – from the medical field, to Earth observations, to providing clean water in underdeveloped countries, to how we diagnose and treat patients in remote areas.

Space station research has led to medication that can help offset the effects of osteoporosis. Space research could also lead to cures for Duchenne Muscular Dystrophy and vaccines for things like staph infection and Salmonella poisoning.

In addition, the technology that went into developing neuroArm, the world's first robot capable of performing surgery inside an MRI, was developed from the Canadarm (developed by MDA for the U.S. Space Shuttle Program) as well as Canadarm2 and Dextre, the Canadian Space Agency's family of space robots performing the heavy-lifting and maintenance on board the International Space Station.

I'd like to expand on some of the ISS science that I find particularly exciting.

WATER RESOURCE MANAGEMENT

Water resource management challenges and hydrological technology development needs are global priorities and provide the opportunity to assert regional leadership.

The challenges of human spaceflight continue to drive innovation in water resource management. Life support systems used in space require water recycling and filtration processes to operate over long periods without potential resupply capabilities. This technology can be applied to address regional water challenges today and in the future.

Similarly to how we reuse waste water on board the ISS, schools in third world countries are utilizing this technology in areas where fresh water is scarce. Last year, a school in Morocco's capitol became the first public facility to use this type of recycling system.

The system relies on a set of organic and ceramic membranes with holes just one ten-thousandth of a millimeter in diameter, which is 700 times thinner than a strand of human hair. These tiny pores filter out unwanted compounds in water, including nitrate – a problematic pollutant that comes from agricultural fertilizers.

Additionally, an orbital complex like ISS can be used for remote sensing purposes, collecting data from space characterizing agricultural productivity, vegetative trends, seasonal ecosystem dynamics, water depth, clarity and sea floor data.

BIOTECHNOLOGY

The biotechnology industry faces significant challenges, given the growing demand for products in the medical, agricultural and environmental fields.

Worldwide research efforts in the areas of molecular and cellular biology to treat and cure human diseases and disorders have exceeded $700 Billion dollars annually. Advances in molecular and cellular biology are essential and necessary to protect and maintain the health of all citizens. New biotech research investigations being conducted in the unique microgravity environment of space are revealing previously unknown biological clues valuable in cancer, genetics and aging research. Unmasking the effects of gravity allows researchers to view proteins as intricate, three-dimensional structures and identify potential medical treatment candidates.

As one specific example, protein molecules crystallized in microgravity have revealed vital structural clues to help identify a viable treatment for Duchenne Muscular Dystrophy (DMD). DMD is the most prevalent form of muscular dystrophy affecting 1 in 3,000 boys (over 50,000 young males in the U.S. today). The average life expectancy of a person with DMD is 25 years and there is currently no cure.

Japanese scientists were able to identify a previously unknown water molecule associated with an inhibitor protein which may be the key to unlocking a potential

cure. In addition to medical applications, advances in Biotechnology research in space may also contribute to development of agricultural land and the reclamation of new lands to satisfy the need for increased agricultural production due to high population growth.

BONE LOSS

In 2010 the FDA approved AMGEN's drug Denosumab, which was used initially for treatment of postmenopausal osteoporosis and subsequently for treatment of bone metastases. Both applications were developed in partnership with the ISS sciences team.

PORTABLE ULTRASOUND TRAINING AND TREATMENT

ISS astronauts were trained to use portable ultrasound to diagnose issues like broken bones and collapsed lungs that might occur on orbit where medical facilities are limited. This same method is now being used to train third-world doctors and care providers to treat patients where modern technology is not available. This training has translated to treatment of more than 40-thousand patients in underserved countries, like Brazil, due to diagnosis through portable ultrasound.

TARGETED METHOD OF CHEMOTHERAPY DRUG DELIVERY; CLINICAL BREAST CANCER TRIALS NOW IN DEVELOPMENT

This treatment has the potential to change how we address cancer—a devastating illness that has touched many of our lives.

Patients receiving invasive cancer treatment must endure ravaging side effects, including nausea, immune suppression, hair loss and even organ failure, in hopes of eradicating cancerous tissues in the body.

Aboard the ISS, a process known as microencapsulation is being investigated, which may be able to more effectively produce tiny, liquid-filled, biodegradable micro-balloons containing specific combinations of concentrated anti-tumor drugs. Using specialized needles, doctors can deliver these micro-balloons, or microcapsules, to specific treatment sites within the patient. Treatments that target cancerous tissues reduce the general toxicity of chemotherapy or radiation to the surrounding healthy tissues. This kind of targeted therapy may soon revolutionize cancer treatment delivery.

<u>Working with NASA and the International Partners to Resolve Technical Issues.</u>

To ensure ISS continues to achieve its science mission, Boeing supports NASA and the International Partners with technical and operations skills for responsive issue resolution.

We work closely with NASA in the ISS Mission Evaluation Room at the Johnson Space Center, providing ongoing mission support for resolution of on-orbit technical and

operational issues. Technical issues are vetted through the NASA flight operations processes, and interdisciplinary problem resolution teams are assigned to investigate root causes and implement solutions.

In addition to the technical support provided by our dedicated ISS personnel, Boeing is able to draw upon technical experts in a full range of engineering and operations disciplines from across the Boeing Enterprise, including our space, defense, and commercial airplanes businesses.

NASA manages the relationship with the ISS International Partners and leads decisions related to technical anomaly resolution. Supporting the NASA role with the International Partners, Boeing maintains international industry relationships that facilitate technical issue resolution.

Because of the ISS, international cooperation remains constant for space and serves as a bridge for other diplomatic discussions. As a leader and the major supporter of the ISS, the United States is in position to continue to champion a global vision for space exploration.

Closing Remarks.

Over the past several years, I've had the opportunity to interact with leaders in countries that are not engaged in the ISS or do not yet have a space program. Without exception, in every one of these conversations about space exploration, people express a strong desire to be involved in space, and more specifically in the International Space Station.

They see the value of ISS – to inspire their youth to pursue STEM education, to create economy-expanding high technology industries, and to provide a significant source of national pride.

For the United States and our International Partners, the ISS provides all these benefits and much more. Fundamentally, the ISS is a one-of-a-kind laboratory facility where researchers are now leveraging the unique microgravity environment of space to revolutionize how we treat medical conditions and manage natural resources. In addition, ISS serves as a valuable prerequisite to advanced space exploration – a place near Earth to test our deep space exploration wings before flying farther beyond low Earth orbit.

Grand as it is, *building* the ISS is not a crowning achievement. We must continue *utilization* of ISS as a practical resource for advancing science, and improving the human condition. And to derive the *full benefit* of ISS, we must use it as a place to ensure our readiness for traveling much farther in space.

We at The Boeing Company are committed to supporting NASA and keeping ISS healthy and continuously capable to support every aspect of its bold mission – improving life on Earth and enabling exploration beyond.

Thank you.