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

John Elbon, Vice President & General Manager, Boeing Space Exploration

Chairman Cruz, Ranking Member Udall, and members of the Committee, thank you for this opportunity to provide Boeing's perspective on U.S. Human Space Exploration Goals and Commercial Space Competitiveness. I am John Elbon, vice president & general manager, Boeing Space Exploration

Mr. Chairman, America's economic growth and competitiveness depend on our capacity to innovate, to reach beyond today's possibilities and stretch farther, faster than our competitors around the world. Our future depends on developing the next generation technologies – but more important are the next generation minds. We need to inspire scientists, engineers, researchers and technologists everywhere by offering the opportunity to be part of something that transcends known boundaries. America needs to reinvigorate that Apollo era passion that changed the world, launching new industries and opening new doors into the universe. From everyday conveniences like scratch-resistant lenses to world-changing satellite-enabled communications, our lives are better today because of cutting edge NASA research innovations – borne of our drive to explore. Just as seafaring ships explored and returned to home shores, bringing unforeseen discoveries – so, too, will `spacefaring nations reap the benefits of our investment in exploration. Robots are great at helping us scratch the surface of new knowledge. Humans ultimately are needed to truly explore – and to pioneer.

NASA research has certainly met the goal of advancing science and technology innovation. This research has energized a strong U.S. economy, providing growth, security and resiliency. The success that U.S. space missions have achieved, and the recognition that these innovations have gained, have made the United States the most attractive global partner for other nations seeking to advance their own space aspirations This plays a significant role in the United States' soft diplomacy efforts to increase U.S. influence in global affairs and in strengthening our alliances.

The international community has aligned with Mars as the ultimate destination, and NASA has in place the programs needed to lead us toward that goal. It starts with the International Space Station as a national laboratory and testbed for future exploration. For affordable crew and cargo resupply to the ISS, NASA has contracted with commercial partners, freeing up funds for NASA to focus on the difficult task of deep space exploration with Orion and Space Launch System as the initial capabilities for deep human space exploration capabilities.

NASA's extraordinary teams have been breaking new ground for decades, returning with innovations that range from medical advances to commercial wonders, using the International Space Station as a unique on-orbit laboratory. The International Space Station has been orbiting Earth for more than 16 years. Astronauts have been continuously living aboard the ISS for 14 years. During an average 6-month period on the station, as many as 200 investigations operate, with between 70 and 100 of them being new studies.

I'd like to spend a minute or two highlighting some of the real science we are seeing from the International Space Station.

Duchenne (du-shens) Muscular Dystrophy: Duchenne Muscular Dystrophy is a recessive form of muscular dystrophy that affects over 1 in 3,000 boys (over 50,000 young males in the US today). Average life expectancy is 25 years.

Research has been conducted on the ISS to identify a treatment or cure for Duchennes Muscular Dystrophy that could lead to identification of a cure due to the unique capabilities of the ISS. The ISS enabled researchers to crystallize an improved complex structure and an associated water molecule not previously known.

Bone loss: The FDA approved AMGEN's drug Denosumab in 2010 – used for treatment of postmenopausal osteoporosis and subsequently for

treatment of bone metastases. Both were developed in partnership with the ISS sciences team.

New Treatment through Ultrasound: ISS astronauts were trained to use portable ultrasound to diagnose issues like broken bones and collapsed lungs that might happen 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.

Closed-Loop Water Recycling on ISS: A closed-loop water recycling system is used on the International Space Station. Not only does this include drinking water, but it includes recycling sweat, urine and even exhaled water molecules.

Similar to how we reuse our waste water on board the ISS, schools in third world countries are utilizing this technology where fresh water is scarce. A school in Morocco's capitol became the first public facility in May of 2014 to use this type of recycling system that reuses urine and waste water.

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 can filter out unwanted compounds in water, including nitrate – a problematic pollutant that comes from agriculture fertilizers.

Targeted method of chemotherapy drug delivery; clinical breast cancer trials now in development: This treatment has the potential to change the landscape for how we address cancer—a devastating illness that has touched many of our lives.

Patients who suffer through invasive cancer treatment can endure ravaging side effects, including nausea, immune suppression, hair loss and even organ failure, in hopes of eradicating cancerous tissues in the body. If treatments target a patient's cancerous tissues, it could provide clinicians with an alternative to lessen the delivery of toxic levels of chemotherapy or radiation.

Aboard the ISS, a particular series of research investigations is making further advancements in cancer therapy. A process investigated aboard the space station known as microencapsulation is 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 a cancer patient. This kind of targeted therapy may soon revolutionize **cancer treatment delivery**.

Imagine the quality of life from such therapies for patients. Remarkably, research that began in space may soon result in such options here on Earth.

The ISS is also a model for international space cooperation, currently counting 15 nations among the international team. The ISS and shared launch systems helped the United States bridge the diplomatic divide with Russia after the fall of the Soviet government and continues to facilitate the development of an integrated, global definition of science and technology policy.

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

With the ISS, we have also demonstrated the ability to build and sustain long term crewed habitats effectively in space. The crews aboard ISS are testing technologies

today that are required for deep space exploration, providing better information about the effects of extended space travel on the human body. In fact, next month astronaut Scott Kelly and cosmonaut Mikhail Kornienko will fly to the ISS and spend one year on-orbit as part of a study that will help us to understand the effects of long-duration, off-planet exposure to our astronauts in preparation for even longer spaceflights to Mars.

NASA has further enabled this path forward by turning over to private industry the routine business of crew and cargo transport for the ISS while NASA concentrates on the development of deep space systems. Two contracts were awarded last September to US companies to provide crewed transportation to and from the ISS starting in 2017. In addition, commercial companies submitted proposals in December of last year for the follow-on commercial cargo contract, which will be awarded this summer.

Boeing is proud once again to partner with NASA to provide crewed services to the ISS. With a heritage dating back from Mercury, Gemini, and Apollo to our more recent history on the Space Shuttle, we have a commercial space program in work that promises to not only secure affordable crew and cargo transport to ISS, but to build an even more robust – unparalleled - aerospace capability for America. The Boeing CST 100 spacecraft combines proven design and spaceflight technology with modern innovation for a reliable and sustainable crew and cargo transportation system.

By leveraging these commercial contracts to support the ISS, NASA is focusing investment in the Orion and Space Launch System, which are critical elements in the future exploration architecture. The December flight test of the Orion crew capsule was flawless, and returned a great deal of data – a huge first step toward Mars. The next test flight for Orion will be on top of the Space Launch System (SLS) for Exploration Mission 1. The SLS provides unprecedented payload capability that can enable human and science deep space missions not previously achievable. We are building the hardware, testing the hardware and production tooling, and installing ground operations for a rocket that will deliver nine times the thrust of the largest private rocket. It is designed to transport the mass and volume necessary to affordably build such an outpost, while safely launching crew deeper into space.

A whole new generation of engineers are building … side by side with experienced space veterans … this next generation rocket.

But you can't build the world's biggest, fastest, most capable rocket with only existing technology. We're also applying innovative approaches to the business, the technology, and the people.

- We are relying on the very best of Boeing and NASA engineers to execute parallel rocket configuration / design with design and installation of the manufacturing facilities. We tapped into the vast resources across the Boeing enterprise to create the most experienced design team.
- By partnering in new ways between engineering and manufacturing we reduced the manufacturing facility footprint and workforce required in assembly & operations. We are using fewer, larger tools to build the rocket by making them multi-use. That cuts down on facility footprint, tooling cost, and workforce required for production. But that also means efficient low rate production (which aligns with NASA funding).
- Using an affordability-driven engineering approach, engineers started with existing hardware and capability to leverage as much as possible current taxpayer investment in space programs. They then innovated to incorporate that hardware to the greatest degree possible, consistently making engineering trades to optimize capability while managing cost and schedule commitments.

This rocket opens doors we've never seriously considered in the past. For the first time in 40 years, the Orion and Space Launch System (SLS) projects will allow astronauts to leave low Earth orbit and completely escape Earth's gravitational field – ultimately opening the door to landing humans on Mars.

Last year, a congressionally mandated report from the National Research Council recommended that the United States pursue a disciplined "pathway" approach that encompassed executing a specific sequence of intermediate accomplishments and

destinations leading to the "horizon goal" of putting humans on Mars. The success of this approach requires a steadfast commitment, international collaboration and a consistent budget that aligns with our nation’s human exploration goals.

We cannot abdicate our place in human spaceflight to other countries that ARE willing to step up, to set aside differences, and align around a path forward. All the right building blocks are in place, right now, for success. NASA’s industry team is leveraging decades of knowledge, hardware, and infrastructure so we can save money and begin with a proven, reliable baseline. NASA is laying the foundation for taking the next important step – human exploration beyond the Moon and to Mars. It is that vision that awakens the explorer in all of us.

Chairman Cruz, Ranking Member Udall, and members of the Committee, thank you again for the opportunity to testify here today and I look forward to answering your questions.