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U.S. House of Representatives

Hearing on "Next Steps to Mars: Deep Space Habitats"
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Chairman Babin, Ranking Member Edwards, and Members of the Committee, thank you for the invitation to testify today. I am pleased to have the opportunity to talk with you about the next steps to Mars.

The technologies we are building today will enable the human exploration of Mars.

Figure 1. The Lockheed Martin team unloads the Orion Crew Module in the Neil Armstrong Operations and Checkout Building at NASA's Kennedy Space Center in Florida to begin full spacecraft assembly for the 2018 Exploration Mission-1 (EM-1).

The Orion spacecraft (Figure 1) was designed from the beginning for human exploration of deep space. The requirements for deep space, such as propulsion capability, re-entry speeds, reliability and redundancy, and the micrometeoroid and radiation environments, are much different than those for low Earth orbit and it is those requirements that have led to the development of a deep-space, human-rated spacecraft capable of missions in excess of 1,000-days. A straight shot, one way to Mars is 35 million miles – or 140,000 times farther than the International Space Station. If you're going, you want a spacecraft built for the long haul that will safely get you there and back.

For example, Orion has:

- radiation hardened avionics and a radiation storm shelter for astronaut safety;
- redundancy in propulsion, computers, and engines, which eliminate the risk of single-point failures;
- a time-triggered Ethernet that is 10 times faster than your internet at home and is capable of allowing the crew to transfer high-rate data like video, all while maintaining vehicle command and control at the same time;
- a life support system that can accommodate exercise by compensating for extra heat and moisture; and
- a thermal protection system designed to protect against the extreme cold of deep space and the extreme heat experienced when facing the sun and during re-entry.

With our own investment, we have conducted studies that verified Orion's Mars re-entry capability and verified our design meets life limit requirements on all parts of the spacecraft required to support multi-year (1,000 day) missions. As you can see, Orion is a key enabler of human Mars exploration.

The future of the Orion spacecraft is a strong one.

Our experience building and flying Exploration Flight Test-1 (EFT-1) – Orion's first flight in December 2014 – has allowed us to improve the build and test processes for Exploration Mission-1 (EM-1). We've made improvements to our factories, manufacturing processes, test schedules, and Orion's mass. For example, the EM-1 Orion spacecraft has been reduced by 4,000 pounds and the time it takes to produce the cutting-edge heat shield has been reduced by 30%. The team has also transitioned to 3-D printed drill templates to very precisely assemble the structural pieces of Orion saving more than $2 million just in the past three months, as compared to our EFT-1 process. These innovations are occurring every day making the spacecraft more affordable and easier to build, which will improve the production time and cost of future Orions.

Orion was highlighted as a flagship program for a NASA small business report noting that more than 800 small businesses from 47 states have played a role in the program's success with their innovative, efficient, and affordable solutions on everything from thermal protection to engineering and procurement services. Orion development has also provided more than 800 products to NASA's commercial crew program since 2011, including technical design data and

test data and results. The innovations required for a spacecraft that will carry humans where they have never gone before is enabling future commercial opportunities and supporting the industrial base.

Our unique and extensive planetary experience (Figure 2) positions us with decades of deep space operations and expertise to apply to the human exploration of Mars.

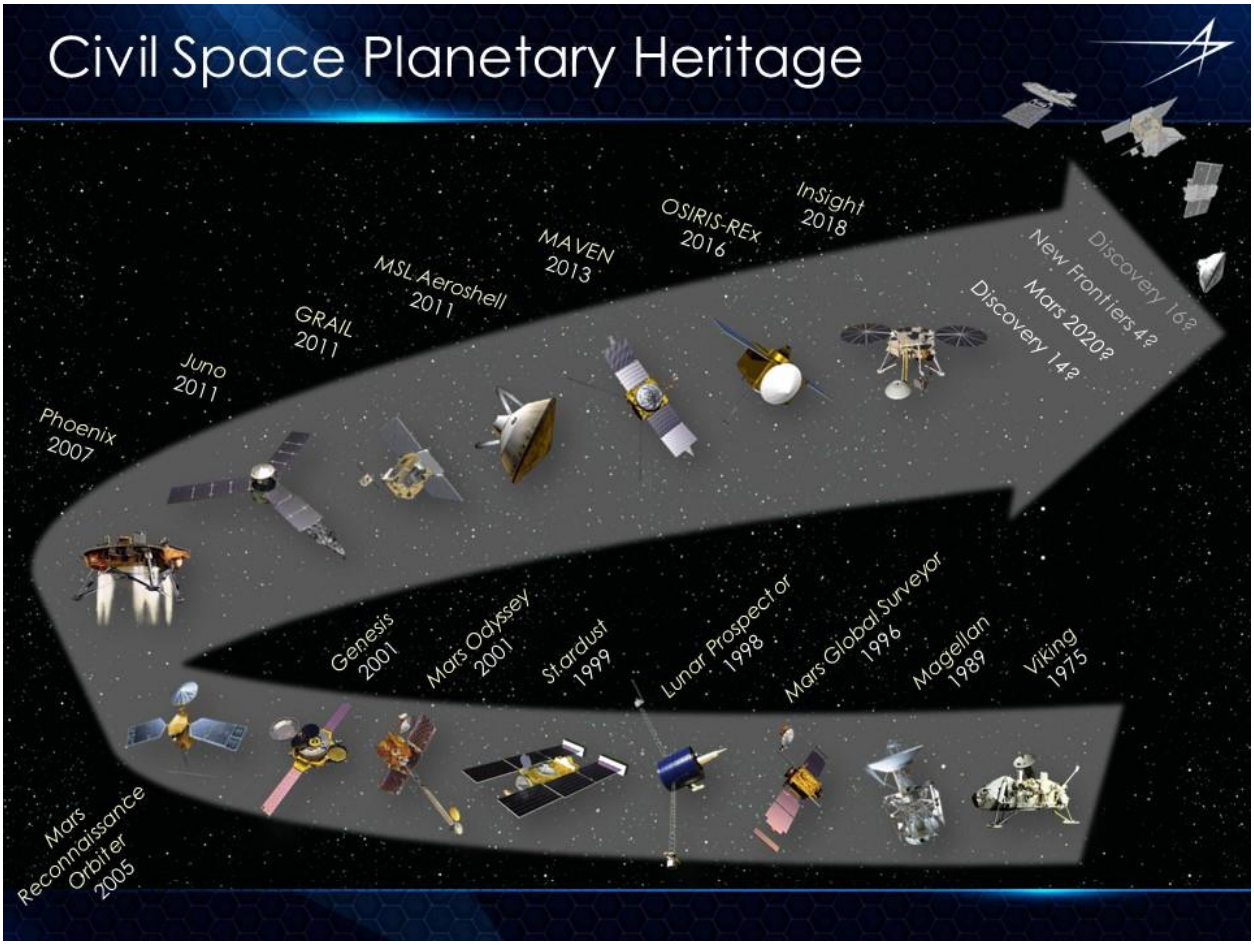

Figure 2. Lockheed Martin Planetary Heritage.

We are currently operating five NASA missions (Spitzer Space Telescope, Juno, Mars Odyssey, Mars Reconnaissance Orbiter (MRO), and MAVEN) from our Mission Support Area at our Waterton Campus in Colorado, as well as operating the Hubble Space Telescope from Greenbelt, Maryland. Notably, we have been continuously operating assets at Mars for almost 20 years. Engineers come into our Colorado operations facility every day taking science measurements, relaying data, and scouting for future landing sites. The question is not "When are we going to Mars?" We are already there. The question is when will we take that next step to get our scientists and engineers out of the office and on their way to Mars as astronauts?

Lockheed Martin has been supporting NASA in the exploration of Mars since the Mariner and Viking Missions of the 1970s – and on every single U.S. Mars mission since. We have

competitively won roles on NASA's Mars missions by providing the best return for the dollar while ensuring the highest probability for mission success. We have done this by making internal investments in landing technologies, remote operations, and onboard spacecraft autonomy to ensure that we continue to be the industry leader in deep space missions.

Since 2000, we have built and launched nine successful spacecraft beyond Earth's orbit while helping to land three more on the surface of Mars. We have two more in development with OSIRIS-REx set to launch in September 2016 and InSight scheduled for May 2018.

InSight – NASA's next mission to Mars – will land a spacecraft on Mars that employs decades of our deep space exploration experience. InSight will study Mars' seismic activity to help us understand the formation, composition, and evolution of rocky planets in the inner solar system. Insight will also measure the sub-surface temperature improving our knowledge of the planet's history, ability to foster life – past or present – and inform us on possible future human habitability.

We're not just working on the here-and-now; we're planning ahead and looking at long-term, viable solutions for the future.

In support of NASA's NextSTEP study contract, we're designing a deep space habitat (Figure 3) that leverages the investment and advanced technology in Orion—technology that is already being designed and built today for deep space. For this Phase I of NextSTEP, the habitat is designed for the "proving ground" in cis-lunar space (Figure 4), or the area around the moon, as a transitional step from low Earth orbit to Mars.

Figure 3. Dr. Dava Newman (center), NASA Deputy Administrator, in a mock-up of Lockheed Martin's cis-lunar habitat at the Lockheed Martin Waterton Campus in Colorado.

By leveraging the functionality already available within Orion, such as power-coupling, communications, radiation protection, and life support systems, we can absolutely reduce the complexity of the habitat and increase its affordability.

Figure 4. Proving Grounds: Orion and the NextSTEP habitat in the cis-lunar proving ground – the next step from low Earth orbit on the way to Mars.

We know that habitats are essential for exploration of the outer bounds of space. We're leveraging our extensive deep space experience and working on concepts that we can continue to build on, adding functionality as needed, and support specific mission requirements as they evolve.

We're not stopping at habitats though.

Figure 5. Humanity Becomes an Interplanetary Species: Artist's rendition of the Mars Base Camp architecture in Martian orbit. By leveraging developed technologies and the taxpayers' investment in SLS and Orion, Lockheed Martin believes a human science Mission to Mars is feasible by 2028.

We have plans to then build upon the systems in-work today to achieve the earliest, most affordable approach for sending humans to Mars - we call this Mars Base Camp and we think we can do it by 2028 (Figure 5).

The concept is simple: transport astronauts from Earth to a Mars-orbiting science laboratory where they can perform real-time scientific exploration, analyze Martian rock and soil samples, and confirm the ideal place to land humans on the surface.

Since before the first Viking lander touched down on Mars 40 years ago, humanity has been fascinated with the Red Planet. Lockheed Martin built NASA's first Mars lander and has been a part of every single NASA Mars mission since.

We're looking forward to humanity's next giant leap and to answering the Big 3 Science Questions: Where did we come from? Where are we going? Are we alone?

Mars is closer than you think. And at Lockheed Martin we're very ready to accelerate the journey.

Thank you. I would be happy to answer any questions you may have.