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**Before the Committee on Science, Space, & Technology  
Subcommittee on Space and Aeronautics  
United States House of Representatives  
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Chairwoman Horn, Ranking Member Babin, and distinguished members of the Subcommittee—thank you for inviting the Commercial Spaceflight Federation (CSF) to discuss our members’ views on the state of the U.S. commercial space industry. We also appreciate the opportunity to review NASA’s plans for the International Space Station (ISS) and to examine future activities in low-Earth orbit (LEO). In addition to NASA’s utilization of the ISS, the United States now has a vibrant, highly capable commercial space sector that is beginning to maximize the utility of ISS and demonstrating a growing LEO economy and demand for operations in LEO, and ultimately closing more business cases. As we look to the future, and transition to a new paradigm in which the Government is one of many customers, the Government needs to reduce burdens on the system by moving at the speed of business.

CSF is the leading national trade association for the commercial space industry, with more than 85 member companies and organizations across the United States. Founded in 2006, CSF is focused on laying the foundation for a sustainable space economy and democratizing access to space for scientists, students, civilians, and businesses. CSF members are responsible for the creation of thousands of high-tech U.S. jobs driven by billions of dollars in investment. Through the promotion of technology innovation, CSF members are guiding the expansion of Earth’s economic sphere, bolstering U.S. leadership in aerospace, and inspiring America’s next generation of engineers, scientists, and explorers.

NASA has embarked on an ambitious effort to commercialize low-Earth orbit (LEO), to establish a long-term presence on the surface of the Moon, and to send astronauts to Mars. These bold commitments should be commended. Over the last two decades, NASA has fostered a nascent domestic spaceflight industry into becoming a highly diverse and capable portfolio of companies. NASA has invested in private development, used its purchasing power to serve as an anchor customer, and enabled private companies to develop, own, and operate their own human spaceflight hardware to serve both public and private needs. Because of the agency’s foresight and meticulous cultivation of this industry, American companies support the critical space exploration and national security needs today, in addition to the commercial marketplace. Unlike when the first modules of the ISS were being launched and assembled in low-Earth orbit, NASA now has a vibrant and diverse commercial marketplace with which it can partner with to achieve its objectives.

Policymakers have recognized the benefits of these kinds of partnerships since the earliest days of the space program. The National Aeronautics and Space Act of 1958 outlines one of NASA’s core missions is: “[t]o seek and encourage, to the maximum extent possible, the fullest commercial use of space.” National Space Policies from both Democratic and Republican administrations have stressed the importance of the commercial space sector. And Space Policy Directives 1, 2, and 3, each issued over the past two years, take further steps to strengthen the partnership between Government and industry and to

remove barriers to industry growth. And, under your leadership, this Subcommittee has taken important steps to facilitate commercial space industry development.

Today, I will outline CSF's perspectives as to how we all can collectively advance our Nation's space goals through innovative, strategic partnerships with American industry.

## **I. The ISS Today: A Vibrant, Highly Capable Commercial Space Sector**

The International Space Station (ISS) is one of the greatest achievements of our time and an unqualified success by any measure. It is an engineering marvel, built and operated in concert with our partners around the world. It is a treasured national laboratory, contributing to key research breakthroughs in science, and it represents the longest ever sustained human presence in space. It is the foundation of humanity's voyage to the stars, and increasingly, a port for commercial activity. In the more than 18 years of crewed operation on the ISS, thousands of researchers on the ground in more than 100 countries have conducted more than 2,500 experiments in microgravity, and with operational cargo flights and, soon, crew flights achieving a steady flight cadence that number will continue to grow.<sup>1</sup>

Thanks in large part to NASA's leadership, pathfinding, and partnerships with the private sector in the decades since, a broad and dynamic space industry has emerged. Since 2000, investors have supported 375 private space companies with nearly \$19 billion of private capital.<sup>2</sup> As NASA continues to drive the frontier outward with groundbreaking research in space, the commercial sector is making space affordable and accessible to everyone.

Today, the United States is enjoying a renaissance in space, with commercial space enterprises playing a leading role. American companies continue to make significant progress driving commercial and industrial use from ISS and LEO. Allow me to update the Subcommittee on the commercial space industry's recent major milestones:

- A growing number of companies are restoring and expanding America's human spaceflight capabilities. This year SpaceX—in close partnership with NASA—will launch American astronauts to space in an all-American system, ending the country's drought on orbital human spaceflight capability left by the retirement of the Space Shuttle in 2011. Already, SpaceX and NASA conducted a successful flight qualification mission of the Crew Dragon spacecraft in March. Virgin Galactic and Blue Origin have flown over two dozen NASA Flight Opportunities Program technology development payloads across these test flights, affording researchers robust and cost-effective access to the valuable microgravity environment. Meanwhile, both companies plan to fly spaceflight participants to space for revenue by the end of the year.
- Sierra Nevada Corporation's (SNC) Dream Chaser spacecraft—in an uncrewed cargo configuration—passed a key milestone in its development to be the third commercial cargo vehicle for the International Space Station.
- Maxar Technologies is looking at feasibility of habitable space platforms for building commercial satellites and how they might unlock new capabilities and business paradigms.
- NanoRacks is the single largest private investor on the International Space Station. The company has invested \$40 million of private capital and its investments continue to grow. Most recently NanoRacks made significant strides in building a new airlock to attach to the ISS, which will be the first permanent commercial structure on the ISS since its construction. The airlock is slated to launch to the ISS in 2020 and NanoRacks has already signed commercial contracts for its use. A couple quick numbers. NanoRacks has launched nearly 800 payloads to the ISS, including 243

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<sup>1</sup> NASA. Available at: <https://spacenews.com/international-experiments-selected-to-fly-on-chinese-space-station/>

<sup>2</sup> Proprietary Data, Space Angels, September 30, 2018.

satellites. Those numbers include payloads from 34 countries over 35 total launches and over \$50 million of revenue.

- The ISS National Lab is a key driver of private activity on board the ISS. Acting as a space integrator, ISS National Lab has more than tripled direct NASA funding through external, non-NASA funding to support a robust industrial R&D portfolio that benefits life on earth. Private sector projects accounted for more than 70 percent of the 74 payloads delivered to the ISS National Lab in FY18. ISS National Lab has directly funded commercial implementation partners, such as NanoRacks and Made In Space, to the tune of over \$30 million in order to support users' R&D work. 15 of the 16 commercial facilities on board the ISS were launched by the ISS National Lab. Finally, the ISS National Lab has launched over 360 R&D payloads to the ISS.
- Axiom and Bigelow are developing commercial space habitats, and each has made major technical progress over the past year.
- Made In Space has developed and demonstrated the ability to manufacture a wide variety of materials and objects in microgravity. These include spaceworthy 3D printable materials, exotic, low loss, high bandwidth optical fiber. These technologies have the potential to disrupt billion dollar industries in telecommunications and satellite manufacturing. Made In Space is also developing several other payloads that will demonstrate the proof of potential of manufacturing high strength, high value metal objects in microgravity, ceramics, industrial crystals, and other materials. Made In Space has more than ten manufacturing payloads in operation or in development for the ISS.
- TechShot will launch the first-ever 3D printer capable of manufacturing human tissue in the microgravity condition of space. These innovations will also provide improved models of disease that could help scientists uncover the mechanisms behind a wide range of conditions affecting people on Earth.
- Space Tango designs, builds and operates facilities on the ISS to support R&D and manufacturing of technology and biomedical applications in microgravity. Space Tango's first platform, TangoLab-1, was installed on the ISS in August of 2016 with a second facility installed on the SpaceX CRS-12 mission in August of 2017. In November 2018, Space Tango unveiled plans for its ST-42 scalable manufacturing platform which is envisioned as an autonomous free-flying facility for on-orbit manufacturing of technology and biomedical products with flights beginning in the mid-2020s.
- Arizona State University has worked closely with NASA over the life of the International Space Station (ISS) to study the effect of the microgravity environment of spaceflight on microbial responses, especially those that are important for causing infectious disease in astronauts and biofouling spacecraft environmental life support systems. These critical factors will not only enable NASA to send humans beyond low Earth orbit (LEO) and travel to deep space, they also provide innovative concepts with potential for translation back to Earth to benefit the general public.

These recent achievements are just a few of many by the commercial industry, and they set the stage for even greater accomplishments the rest of this year and beyond for a broad set of stakeholders.

## **II. Maximizing use of the International Space Station and Transitioning to Commercialization and Industrialization**

20 years after Americans launched *Unity*, the first of three node modules of the ISS, President Trump, NASA and Congress have established a national commitment to ensure American leadership in low-Earth orbit—not just as a quick pass-through to cislunar space and the Moon, but to establish a permanent human presence in low-Earth orbit and enable the development of a sustainable commercial and industrial

ecosystem. This will foundation provide the spaceflight community a valuable proving ground for NASA's goal of being one of many customers for commercial services and capabilities in LEO.

This ambitious objective should be applauded and, if executed appropriately, will serve to reinforce American leadership in space as international competitors like China focus their own efforts in low-Earth orbit. In June 2019, China announced that 17 nations will fly nine experiments on the Chinese Space Station.<sup>3</sup> The Chinese Space Station will provide external platforms for experimental payloads and 16 experiment racks that can support 11 disciplines such as space medicine, life science, and microgravity physics and material science. Opening up the Chinese Space Station to international participation is part of a wider effort by China to demonstrate its own technological growth while diminishing the perception of American superiority. It seeks to strengthen its own diplomatic ties with various nations by offering new opportunities to stimulate their space technology and science sectors without the United States.<sup>4</sup> To retain its leadership in space exploration, the United States must ensure it remains the premiere spacefaring nation in low-Earth orbit—and American private industry is here to help.

Long-term, sustainable human presence and commercial activity in LEO requires an integrated effort that includes stimulating greater demand for space-based industrial R&D, and spaceflight products and services in LEO; the development of commercial space stations and space habitats, and routine transportation of astronauts and cargo to and from LEO. Public-private partnerships with commercial companies are fundamental to developing these capabilities. NASA's fiscal year 2020 budget request and Low Earth Orbit Economy initiative prudently highlight partnerships with commercial providers as a key tenet of this strategy.

Undeniably, NASA and its partners have conducted incredible, groundbreaking work aboard the International Space Station, and the Nation now proudly has the longest continuous human presence in space in history. As we consider our options for the future, we should look to build upon these achievements by leveraging the capabilities provided by a new commercial revolution in space. CSF companies are proud to be playing a role in this new era.

### **III. The Future of Low-Earth Orbit**

As this Subcommittee looks to how best ensure the country's ongoing leadership in space, it must carefully review commercial LEO efforts to ensure responsible use of finite taxpayer dollars and to encourage, rather than hamper, rapid innovation.

Last month, NASA released guidance for its Low Earth Orbit Economy initiative. These plans and policies include pricing for facilities and resources that may be accessed on a reimbursable basis by commercial entities onboard the ISS; an announcement of opportunity and associated costs to fly private astronauts; calling for proposals on opportunities to stimulate demand, a commercial use policy for the ISS, and other initiatives. CSF commends Administrator Jim Bridenstine and the entire NASA team for recognizing the success of the commercial industry, incorporating best practices learned from the agency's years of partnership with private companies, and updating its strategic objectives to accelerate additional development of these important capabilities.

As NASA works to implement its Low Earth Orbit Economy initiative and expand human presence in space, CSF recommends the following:

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<sup>3</sup> China Daily, "17 nations to join China's space station," June 2019. Available at: [http://www.china.org.cn/china/2019-06/13/content\\_74883265.htm](http://www.china.org.cn/china/2019-06/13/content_74883265.htm)

<sup>4</sup> Space News, "International experiments selected to fly on Chinese space station," June 2019. Available at: <https://spacenews.com/international-experiments-selected-to-fly-on-chinese-space-station/>

- Encourage NASA to adopt the best elements of its successful efforts to commercialize space, such as the Commercial Orbital Transportation Services (COTS) program and the Commercial Crew program. Whereas traditional cost-plus contracts can perversely incentivize companies to run over budget and behind schedule, NASA properly structured its commercial partnerships to develop new space capabilities at a rapid pace by implementing milestone-based agreements for development and firm-fixed-price contracting for services.
  - The COTS Program to develop uncrewed cargo resupply capabilities has been a clear success for NASA. A 2017 NASA Cost Analysis review of the program was direct in its assessment of the benefits of true public-private partnerships: “the COTS development and later the operational Commercial Resupply Services (CRS) are significant advances in affordability by any measure.”<sup>5</sup>
  - NASA’s Aerospace Safety Advisory Panel (ASAP), the most conservative and safety-focused group within the agency, identified the commercial, competitive structure used under the Commercial Crew program as a preferred model for NASA’s future development activities for human spaceflight systems, particularly in NASA’s return to the Moon.<sup>6</sup>
- Maintain competition throughout a program’s life, instead of just during the bidding process, to encourage ongoing innovation and cost-reduction. Multiple operational providers also offer redundant capabilities to assure NASA’s access to space in the event of delays or technical challenges with one system.
- Support the full and complete utilization of the ISS through at least 2028, and a timely, seamless transition process towards commercial space stations to ensure that the United States maintains a continuous crewed presence in LEO. Continued industrial research and development activities on the ISS in the immediate term will identify new markets or new applications in space and inform future platform development.
- One of the most important things that the Government can do for the LEO economy is to provide certainty and predictability in the LEO marketplace by developing and communicating a clear plan for the transition to commercial systems. It also means that if NASA is going to charge for ISS-related services, those prices should change infrequently and with substantial advance notice. Above all, NASA must resist the temptation to try to make money now, at the expense of future LEO market expansion: this would be the very definition of “killing the goose that lays the golden eggs.” The ISS was created for non-economic reasons, and it should not now have to be justified entirely on its near-term economic value.
- Regularly engage with industry to understand and continually incorporate new commercial capabilities as they evolve, as opposed to requesting that business fit into solely within NASA’s plans.
- Support uses of the ISS that are based on scalable business models, and then support the scale-up of those models with consistent and plentiful access to upmass, operations, and downmass.
- Invest in “proof of potential” payloads and business models to identify potential markets for LEO commercialization.
- Grant users complete control over intellectual property developed on the ISS.
- Avoid competition with private industry. Simply put, the domestic commercial industry will not mature if the world’s largest and best funded space agency is competing with it. As a key example, NASA should not provide “free” space transportation to countries that are not already participants in the ISS program. These countries would otherwise commercially procure seats to space for their astronauts on American suborbital and orbital spaceflight systems.

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<sup>5</sup> Zapata, Edgar. An Assessment of Cost Improvements in the NASA COTS/CRS Program and Implications for Future NASA Missions. American Institute of Aeronautics and Astronautics, 23 Oct. 2017, <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170008895.pdf>, pp. 1.

<sup>6</sup> <https://spacenews.com/safety-panel-calls-on-nasa-to-apply-commercial-crew-lessons-for-artemis/>.

- Support the increased use of ISS as a destination for private astronauts, as well as support for new commercial LEO platforms.
- Stress the importance of short-duration, “sortie” missions to the ISS. These missions, lasting one to two weeks in length, offer NASA the opportunity to conduct more frequent missions to space, promising greater scientific discovery and more opportunities for the astronaut corps to go to space than the current six month rotation missions allow. To reduce costs to the taxpayer, NASA should purchase seats on commercial missions to ISS to allow for a mixed NASA / commercial crew on these missions. Not only would this mission architecture better support NASA’s objectives, it would also support the development of a marketplace for private passenger transportation to space.
- Establish a national microgravity policy initiative, informed by a Microgravity Decadal Survey. Microgravity research will stimulate the next technological and economic changes for the United States. As policy has recognized the importance of investment in artificial intelligence, similar policy needs to be established should foster the pursuit of innovation, technology development, and discovery where public.
- Microgravity Decadal Survey – microgravity research and development is critical to American leadership, discovery, exploration, and the development of the space economy. NASA, the National Science Foundation (NSF), and the National Institute of Health (NIH), should jointly fund the National Academies of Sciences, Engineering, and Medicine to carry out a microgravity decadal survey.
- Enhance utilization of the Flight Opportunities Program (FOP) for suborbital microgravity research. The Flight Opportunities Program enables low-cost access to environments where cutting edge research and development can be conducted. The Flight Opportunities Program is a key component of a microgravity R&D pipeline that contributes to the development of a robust low Earth orbit ecosystem. This pipeline can be strengthened by broadening the Flight Opportunities Program user community to include universities and academia, by allowing basic and applied science payloads to fly in addition to technology development payloads, and by enabling principal investigators (PIs) to fly alongside and tend to their payloads during flight.
- Assume a long-term view of LEO commercialization and avoid “taxing” early commercial efforts as a means to fund ISS operations or deep space in the short term.

#### **IV. Conclusion**

With the technological advancements and increased knowledge achieved through decades of work by NASA in deep space, including Mars, the United States is now well-positioned to build upon and surpass our past achievements in space. With NASA resources and expertise, coupled with American ingenuity, the principles of free enterprise, and the benefits of competition, the United States can do more in space than has ever been accomplished previously. We just need to appropriately recognize and leverage our advantages.

At long last, as we approach the half-century mark of the Apollo 11 mission, we are seeing the commercial sector investing in a broad swath of activities in partnership with NASA, from LEO to the Moon and beyond. We must further and accelerate this momentum, and CSF members know that anything is possible when you unleash the full innovative capacity of American industry.

We are ready to take the next step with NASA, and we look forward to continuing to work with this Committee to establish a permanent human presence in low-Earth orbit and enable the development of a strong commercial ecosystem. Chairwoman Horn, Ranking Member Babin, I appreciate your invitation to testify before the Committee today. Thank you for your attention, and I look forward to your questions.