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Hearing on Examining the Future of the International Space Station: Stakeholder Perspectives  
Subcommittee on Space, Science and Competitiveness  
Committee on Commerce, Science and Transportation  
United States Senate  
512 Dirksen Senate Office Building  
Washington, DC 20002  
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Dear Chairman Cruz, Ranking Member Markey and Members of the Subcommittee,

From 2005 to 2015, as NASA's International Space Station (ISS) program manager, I oversaw the development, assembly, operation and utilization of the International Space Station (ISS), for the United States government and the other 14 nations invested in the program. I retired after 27 years of government service, and later co-founded Axiom Space, whose goal is to build, launch and operate the world's first commercial space station. We are dedicated to making living and working in Earth orbit commonplace, as a means to sustained human deep space exploration. We plan to build a commercial successor to the ISS, first attaching our modules to it, and then ultimately separating from it when ISS is retired. We have an extraordinary team of seasoned space and business professionals. With decades of engineering, operations and management experience in human spaceflight, we are uniquely equipped to take the baton from the remarkably successful ISS, continue its legacy in low Earth orbit (LEO) and facilitate the extension of America's leadership among spacefaring nations.

Throughout the course of modern history, it has been the role of governments to open new frontiers. The Catholic Kings financed the voyage of Christopher Columbus that ultimately discovered the New World. President Thomas Jefferson commissioned the expedition of Lewis and Clark that began the westward expansion in the United States. When the risk – personal or financial – is high, and the reward uncertain and/or many years into the future, it is appropriate for governments to expend state resources in the interest of their citizens. Once security is established, a market is identified and revenue appears nearer term, it is likewise appropriate for state actors to step aside in favor of entrepreneurs, and to allow commerce to develop. Human presence in LEO is ripe for such a transition; adhering to the following strategic elements will provide the highest likelihood of a successful evolution to a vibrant and robust commercial marketplace in LEO.

### **Ensure Continuous Access to LEO**

As NASA begins to shift its human spaceflight focus – and, by necessary consequence, its budget – from LEO to exploration of cis-lunar space, one concept must remain inviolable: In order to preserve our leadership in space, the United States must not relinquish uninterrupted access to LEO for its astronauts. Needless to say, this includes both a way to get there, and an orbiting platform on which to continue the important activities underway today aboard the ISS.

Human deep space exploration will require the continuation of several tasks that are either already underway or planned for execution aboard the ISS. One is continued research into understanding the responses of the human body to the space environment. NASA's Human Research Program has been very successful in retiring many risks toward a notional Mars flyby mission, but one set of investigations that is not scheduled to be complete before ISS retirement, even assuming a retirement of 2028, is on the effects of space radiation exposure.<sup>1</sup> Secondly, microgravity can negatively affect machines as well as man. The ISS has suffered the unexpected failure on-orbit of systems that were thoroughly tested on the ground. Some broke down in the first few hours of operation; others after months of successful run time. With these systems in LEO, while neither simple nor inexpensive, the logistics involved with repairing them were relatively straightforward. Ultimately, the crew was always a short flight back to Earth if the repairs were not successful. However, in a distant lunar retrograde orbit – or, worse, on the way to Mars – such logistics would be orders of magnitude more complex, if not impossible. For this reason, it is imperative that critical hardware be thoroughly tested in LEO before such systems are deployed to deep space, and a platform on which to do so is crucial. The need for this capability in LEO will be continuous for a sustainable human exploration program because as new technologies are developed to better serve exploration, the technology and the resultant systems will need to be thoroughly tested in LEO before being deployed on missions further from our planet. Finally, current plans for NASA's Lunar Orbiter Platform-Gateway reflect no more than annual crewed missions of 30-day duration with astronauts from several participating countries. This cadence will severely strain NASA's ability to maintain an experienced and proficient astronaut corps. A readily accessible LEO destination will be a vital proving ground where astronauts can gain valuable spaceflight experience in preparation for more challenging deep space missions.

As important as the considerations of human research, critical systems hardware testing and astronaut proficiency are, the principal argument for the U.S. to maintain uninterrupted access to and a destination in LEO is intangible – to safeguard our position as the world's preeminent spacefaring nation. We are clearly in that position today, thanks to our leadership of the ISS partnership. But with Europe having expressed its pivot toward the Moon before us, and the impending launch of China's Tiangong-2 space station, our place at the head of the class may be in jeopardy. The mission sequence planned today for human deep space exploration – which may not begin for close to a decade – may not be of sufficient frequency or duration to maintain the interest of other nations. But there will always be useful work to do aboard a LEO platform that will appeal to nation states with astronauts. It is therefore imperative that there be no gap in access between the platform of today – the ISS – and its American commercial successor.

### **Award the Port**

While it is certainly possible to develop and launch a free-flying commercial space station, there are numerous advantages to starting with one or more modules attached to the ISS, and then to separate them prior to the lowering of the ISS altitude in preparation for its deorbit. With modules attached to the ISS, a company can use revenue generated from their utilization to offset capital

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<sup>1</sup> NASA Advisory Council Human Operations and Exploration Committee, March 2018, [ISS Status and Transition](#), p. 13

requirements and consequent investment needs. More importantly, such an arrangement would allow a commercial operator more time to establish a viable customer base, and would permit NASA to transition not only research that is underway on ISS, along with attendant hardware, but also that of National Lab customers. Being able to transfer useful research and manufacturing hardware from ISS to a new platform on orbit when ISS is retired will save significant costs (avoiding having to rebuild and launch new hardware), ensure the ISS is utilized to the maximum extent possible even as it nears retirement, and perhaps most importantly, protect the LEO marketplace that will have developed at that point. Finally, NASA will have less insight into the design and development of commercially provided modules; having them attached to ISS for a period of time will give NASA and other ISS partner government space agencies an opportunity to gain experience not only with the modules but with how their commercial provider operates and protects the crew and spacecraft. There is clear benefit to both the government and to the commercial space station developer to attach one or modules to the ISS via one of its berthing ports.

In the summer of 2016, NASA issued the Sources Sought solicitation “Advancing Economic Development in Low Earth Orbit via Commercial Use of Limited Availability, Unique International Space Station Capabilities.” In it, NASA stated:

NASA will use the results of this RFI to guide development of a possible future announcement of opportunity appropriate to the Agency's objective of fostering a self-sustaining commercial marketplace in LEO. NASA is seeking industry ideas to stimulate economic development through the use of unique ISS capabilities such as unused common berthing mechanism (CBM) attachment ports, non-standard attachment sites or any other capability which can be used in a way not previously envisioned.<sup>2</sup>

Responders were given six weeks to respond. Now, almost two years later, industry is still waiting for the “announcement of opportunity.” In the meantime, in its FY2019 President’s Budget, the Administration has expressed a desire to defund the ISS as early as 2025, rather than the date presumed by many of 2028. These two events combine to reduce the time available for developing a robust, commercial market in LEO by up to five years. And the clock is still ticking. NASA recently released a Research Announcement (NRA) for the “Study for the Commercialization of Low Earth Orbit.” This solicitation “. . . grants no rights for use of or guarantee of any ISS port obligation.”<sup>3</sup> With the NRA schedule showing awardees being selected in June or July, contracts to be finalized in August, and study products due in December 2018,<sup>4</sup> if these studies will be used

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<sup>2</sup> Federal Business Opportunities, [Advancing Economic Development in Low Earth Orbit via Commercial Use of Limited Availability, Unique International Space Station Capabilities](#)

<sup>3</sup> NASA Solicitation and Proposal Integrated Review and Evaluation System, Study for Commercialization of Low Earth Orbit, [Announcement](#), p. 8

<sup>4</sup> NASA Solicitation and Proposal Integrated Review and Evaluation System, Study for Commercialization of Low Earth Orbit, [Industry Day Charts](#), p. 15

only to *inform* the aforementioned announcement of opportunity to compete for the berthing port, it is reasonable to expect the awarding of the port will occur no earlier than 2020.

It is difficult to imagine that an investor would commit a significant outlay – the kind necessary to build one or more space station modules – to a commercial company that doesn't have access to an ISS berthing port. The start of construction, which will take several years to complete, depends on this investment, which in turn depends on the award of a berthing port. Once the module(s) is complete, it must be launched, berthed and integrated with the ISS. And, of course, all of this must occur before any customer could utilize the module. So, the award of a berthing port to a company is the first domino that must fall in a chain of events, each of which relying on the previous, that will lead to a sound decision that the nation is ready to transition its human LEO activities from the ISS to one or more commercial operators. Each day NASA delays this port award, it correspondingly postpones the moment when it can reasonably shift its ISS operations budget to that of deep space exploration.

A much more efficient course of action would be for NASA to announce a fair and open competition for the right to use the ISS Node 2 forward berthing port *in parallel with*, rather than following, the NRA studies. NASA could establish criteria for the port solicitation utilizing the considerable information provided in response to the summer 2016 “Advancing Economic Development in Low Earth Orbit via Commercial Use of Limited Availability, Unique International Space Station Capabilities” RFI, which reportedly resulted in responses from 19 industry partners. When the reports awarded through the “Study for the Commercialization of Low Earth Orbit” NRA are submitted at the end of this calendar year, NASA would verify the consistency between those studies and their competitive process, make any adjustments necessary as a result, and could be ready to award use of the berthing port to a company within a month or two, rather than only *then* commencing to develop a process to award the port. The parallel approach could save up to a year, accelerating by the same amount the investment necessary to build the successor to the ISS, and ultimately advancing the moment when a viable commercial platform would allow NASA to shift its focus from LEO infrastructure sustainment and operation to deep space exploration.

### **Build Demand**

The FY2019 President's Budget includes \$150M for LEO Commercial Development. As a commercial space station company, you might reasonably expect that Axiom would like to receive some of that money to put toward design and building of one or more modules. We do not. To award contracts for development of hardware is to put NASA funding and extensive development requirements in the critical path for success, and threatens to hold the Agency hostage in the event the awardee would need more money to complete their design and build. Although the Commercial Orbital Transportation System agreements and follow-on Commercial Resupply Services contracts were both innovative and successful, NASA is the only customer for those services, and without its funding, the companies would surely discontinue manufacture of the Dragon and Cygnus spacecraft. To avoid being put in the same posture when it comes to a commercial orbital platform, NASA should give priority to companies who raise their own capital, instead of asking for government funding. These firms will be more incentivized to succeed and therefore to grow LEO demand beyond merely the government customer; their survival will depend on it. The only

way for NASA to eventually divert much of the almost \$3.5B that it's spending today on ISS to deep space exploration is by NOT being the anchor tenant. A truly commercial platform will succeed only if it has multiple customers – both private and government. In the short term, NASA's role should be limited to making unique ISS resources available for potential commercial partners, and to stimulating demand for on-orbit services. When NASA is the only customer, there is no driver to create demand. Public-private partnerships in this case work best when the public promotes expansion of the demand, and the private spends its own capital to satisfy it.

It is important for NASA to be judicious in selecting its partners for commercial development of LEO. Since the ISS cannot support more than one large commercial station provider, NASA should pick the one that has the best chance of success, based on the technical merit of their design, the soundness of their business case, and the pedigree of their team. It should also acknowledge that demand will be, at least in the beginning, limited. Picking more partners than there is demand to satisfy will result in the failure of the market for LEO services to develop. This further highlights the imperative that NASA use whatever funding it receives for LEO commercial development to stimulate demand, and limit supply side help to the right to use unique ISS capabilities, such as a berthing port.

### **Don't Compete with Industry**

Finally, one of the principal revenue streams that commercial space station companies are pursuing is human spaceflight for astronauts from other nations. The ISS partnership distributes flight opportunities based on each partner's contribution to the project. Outside of these allocations, NASA should not also offer flights to other nations either inside or outside the ISS partnership, as this directly competes with the offerings of commercial companies and would severely diminish the addressable market available to them today. This would not only be in violation of National Space Policy,<sup>5</sup> it would be counterproductive to the development of a sustainable commercial market for LEO services.

In summary, we cannot afford for the transition of the United States' human presence in LEO from the ISS to one or more U.S. commercial platforms to be unsuccessful. Ensuring continued access to a LEO platform for our astronauts will maintain our position as the world's leading spacefaring nation. Second, to achieve this transition in a manner that allows the resources currently being allocated to ISS to be eventually diverted toward human deep space exploration, NASA must issue an opportunity for companies to compete for the ISS berthing port as soon as possible. Third, any funding made available to NASA to help develop a commercial capability in LEO should be spent on building demand. Finally, NASA should be mindful of not competing with industry.

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<sup>5</sup> National Space Policy of the United States of America, June 28, 2010, p. 10