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International Collaboration and Competition in Space: Oversight of NASA's Role and Programs

I. Introduction

Chairwoman Cantwell, Ranking Member Wicker, Subcommittee Chairman Hickenlooper, Subcommittee Ranking Member Lummis, and distinguished Members of the Committee, I'm grateful to all of you as well as your intrepid staff for the opportunity to testify regarding the vital topic of international collaboration and competition in space.

All of us in the space industry are explorers. However, we're not just exploring the depths of space, we're also exploring new international relationships and innovative partnerships with the private sector. The benefits gained from such activities creates tremendous value and is a critical part of our nation's journey into the final frontier.

In today's geopolitical environment, maintaining and growing our international relationships in space has never been more important. The space environment challenges us in a singularly harsh manner. Space is a crucible that demands the formation of global coalitions to bear the extraordinary difficulties and risks of exploration and development. International partnerships are not just a luxury but a necessity, and the U.S. is at an inflection point where our nation's ability to lead future global coalitions will either be bolstered and revitalized or undermined and substantively damaged.

II. Sustaining the Continuity of Artemis

In regard to beyond low-Earth orbit (LEO) human space exploration, our nation has, unfortunately, struggled to maintain its focus. Numerous beyond LEO human spaceflight programs have been initiated by NASA only to face termination by a subsequent Presidential Administration or Congress. The Vision for Space Exploration, the Constellation Program, and the Asteroid Retrieval Mission, are just a few of the initiatives our country engaged in which did not come to fruition. This failure to sustain a beyond LEO human spaceflight strategy has not gone unnoticed by our international partners. Our colleagues in Europe, Japan, Canada, and across the world have in many ways born the brunt of our national inability to execute on a proposed vision. This pattern of inconsistency has substantively damaged U.S. credibility on the global stage and has forced partner nations to question their relationship with the U.S. in space exploration.

As the Acting Associate Administrator for the Office of International and Interagency Relations ("OIIR"), I was often exposed to this growing skepticism of NASA's ability to sustain a beyond LEO human spaceflight program. My first overseas trip upon joining NASA in 2019 was to Paris to conduct negotiations for the European Space Agency's ("ESA's") contributions to the Gateway. My enthusiasm for international collaboration was met with justifiable skepticism from our European partners about whether the Gateway and Artemis would be sustained or, like previous NASA beyond LEO human spaceflight plans, would fade away and fail due to changing political priorities and/or a lack of funding.

Despite this skepticism, the OIIR team and our State Department counterparts managed to convince not just ESA's leadership, but the Japanese and Canadian governments that Artemis would be different. My primary argument was the bipartisan support that Artemis enjoyed. At the time I pointed to support from several Democratic policymakers, including the Chair of this Committee, Senator Cantwell, for the general goals and structure of Artemis. I personally reassured foreign officials that then NASA Administrator Jim Bridenstine was keenly aware of past history, and he was making every effort possible to build a bipartisan coalition which would sustain Artemis through any future changes in leadership in the White House or Congress. As a matter of fact, I was brought to NASA by former Administrator Bridenstine specifically to build a global coalition since he viewed such international partnerships as the key to sustaining the Artemis program.

Again, despite justifiable skepticism, our international partners agreed to join us and executed binding agreements in support of the Gateway. This support was manifested by the commitment of billions of dollars of international contributions toward building hardware for the Gateway and the Artemis program. Our international partners have embraced Artemis, appropriated substantial funding, and built their own plans around our strategy. In return, the U.S. cannot equivocate, turn back, or show anything less than the steadfast commitment that our international partners have already demonstrated.

Over the course of decades during which the U.S. struggled to sustain a beyond LEO human spaceflight program, the world has changed. China now represents a capable and attractive partner which is courting even our closest allies in Europe, Canada, and around the globe. In stark contrast to NASA, the Chinese space program has enjoyed unwavering political direction and consistency relative to their lunar plans. In the eyes of many, China represents a reliable alternative partner to the U.S. that does not suffer from the vicissitudes of the American political system and is rapidly growing its space-related capabilities and expertise.

Therefore, clear and explicit support for the Artemis program has never been more vital. The U.S. can no longer afford to change direction and must continue to embrace the Artemis program in a bipartisan fashion to preserve American credibility and our nation's ability to assemble and lead the global coalitions that are necessary to succeed in space exploration.

For all of these reasons, I applaud the Biden administration for maintaining the continuity of the Artemis program with enthusiasm and alacrity. It was an honor to serve with then Acting Chief of Staff and Senior White House Appointee, Bhavya Lal, whose outstanding leadership

allowed the Agency generally and Artemis specifically to emerge from the transition, which are always difficult periods, with clarity and constancy of purpose. Moreover, your former colleague and now NASA Administrator Bill Nelson has provided strong and consistent leadership and enjoys a close relationship with the President as well as the Congress which is vital to successfully implementing Artemis.

I would also be remiss if I did not commend the bipartisan leadership of Jim Bridenstine, including reaching across the aisle to place our current Administrator on the NASA Advisory Council. Administrator Bridenstine's unflagging efforts to build a broad and deep political coalition helped to ensure the future of Artemis. I will never forget when, after participating in a Women's Equality Day event at NASA Ames, Speaker Pelosi stated her support for Artemis by instructing the Administrator to work on getting the first woman to the Moon as quickly as possible. Subsequently, Vice President Pence tweeted about the Speaker's message thanking her for the support. Such alignment between two political rivals is all too rare, and kudos to Jim Bridenstine for his efforts to bring disparate leaders together in support of the Artemis program.

Of course, this Committee and its staff has consistently served as a shining example of bipartisanship. In my various private sector positions and while at NASA, I was always grateful for the vision and unparalleled bipartisan nature of the Commerce Committee's space policies. Under both Democratic and Republican control, including during Senator Nelson's tenure, this Committee has represented the best of Capitol Hill, always striving to find common ground and bridging divides.

Now, more than ever, we need bipartisan leadership, which is why Congress passing a NASA Authorization Bill is of paramount importance. As I described previously, it's vital for the U.S. to present a unified vision to both allies and rivals. The best way to accomplish this is through a bipartisan NASA Authorization which includes strong and explicit support for the Artemis program. I want to thank and congratulate this Committee for crafting a NASA Authorization as part of the U.S. Innovation and Competition Act (USICA) of 2021 which has been passed by the Senate. It's critical for the House of Representatives to also take action and for Congress to adopt a reconciled bill as expeditiously as possible. Both partner and rival nations have a sophisticated understanding of the Congressional process. The lack of a bipartisan NASA Authorization bill sends a negative message regarding America's ability to move forward with a unified vision for space exploration. Therefore, this issue must be rectified quickly before it leads to inevitable doubts and concerns that will damage America's ability to execute the critical global partnerships that are such an important part of the Artemis program.

III. Avoiding a Space Station Gap

Another area where policy consistency is critical is in LEO. The venerable ISS, which has now supported a continuous crewed presence for over twenty years, stands out as a dramatic success for American global leadership and policy continuity. Thanks to the ISS, the U.S. has been a hub for an unprecedented partnership that defines the present and will influence the future of human space exploration. An entire generation has been born and grown to adulthood never knowing a world where there isn't an international team of scientists living and working on a

space station. I believe that far too often we take this extraordinary accomplishment for granted. Having negotiated the binding Memorandums of Understanding for the Gateway which were based on the ISS's Intergovernmental Agreement, I have a great personal appreciation for the difficulty of assembling the ISS coalition as well as maintaining it. I have always felt that the ISS should receive a Nobel Peace Prize acknowledging the herculean work of those who transformed the station from dream into reality.

Yet again, I would like to thank the Committee for including in the NASA Authorization Act, which passed the Senate, language extending the ISS to at least 2030. The ISS still remains the pinnacle for human spaceflight and we should leverage the station's singular capabilities for as long as possible. Again, Congress adopting an authorization bill extending the ISS will be extraordinarily important to provide our international partners with certainty relative to the future of the station.

Moreover, per the commendable authorization language passed by the Senate, America's goal is to maintain a continuous human presence in LEO. Extending the ISS is an important part of achieving this objective, but of equal importance is ensuring that when the ISS is retired, there is a commercial space station that will carry on its legacy. The ISS itself took decades to construct and America now faces the troubling prospect of a space station gap. The U.S. can ill afford to lose its presence in LEO. Astronautics opportunities, which are the grist for the mill of international collaborations, will always be more plentiful in LEO than for beyond LEO operations. Additionally, we're only now beginning to realize the incredible potential of microgravity manufacturing, research, and development. The microgravity environment represents an entirely new arena for trailblazing scientific and commercial endeavors. What we will learn from and what we can do in microgravity has the potential to revolutionize fields as diverse as drug treatments and medicine to communications, agriculture, and construction.

America cannot lose access to this unique environment at exactly the time when others are beginning to establish a foothold in LEO. Specifically, over the course of the past year, China has launched its own space station which has now received both resupply missions and astronauts. Only a few days ago, China launched their most recent crew to their station, beginning the longest duration mission Chinese astronauts have ever undertaken. Moreover, China is aggressively courting our existing ISS partners, particularly in Europe, to join their new crewed LEO operations. Again, for two decades the ISS has allowed the U.S. to serve as a hub for global astronautics activities. As the world's leading Democracy, we must not cede the substantial diplomatic and political soft power benefits of crewed space station operations to China or any other nation.

Moreover, a space station gap would have a dramatic negative impact on American launch capabilities. Losing the demand for commercial cargo launches to the ISS as well as commercial crew (not long after investing billions of dollars to develop this capability), would impede gaining experience with these systems as well as continued innovation and growth. The damage done to American launch capabilities and international competitiveness would hurt our overall industrial base creating issues not just for civil space operations but for national security space activities as well.

Avoiding a space station gap will not be simple or easy. Developing and deploying a new space station is a nontrivial effort that could take a decade or more. NASA is wisely turning to the private sector to leverage commercial innovation and efficiencies to build and operate this new station. I'm excited to see NASA's Commercial LEO Destinations ("CLD") program progress taking us a step closer to ensuring that the U.S. and our partners maintain a continuous human presence in LEO. At Redwire Space, we are the only organization that has ever successfully printed objects on the ISS and we are a global leader in microgravity manufacturing and R&D. We will apply our company's singular capabilities and experiences with microgravity manufacturing, along with our innovative roll out solar arrays, robotics, digital engineering, sun sensors, star trackers, and other technologies to ensure the success of the CLD effort.

Finally, I want to applaud this Committee for passing language that reinforces America's commitment to maintaining a continuous presence in LEO through the development of a commercial space station. I hope that the House moves forward quickly with a NASA Authorization Bill which includes identical language allowing Congress to send an unequivocal message to partners and allies alike that we have learned from history and that this nation stands united in support of preventing a space station gap.

IV. Maintaining Technological Leadership Through Public-Private Partnerships

There can be no question that we are in a great powers struggle with China. This rivalry extends to space where the implications of the U.S. falling behind China technologically would have devastating consequences. This is a race that the U.S. cannot afford to lose, however, in many critical areas we are already facing the prospect of falling behind. Specifically, the U.S. must redouble its efforts to support next-generation space-based robotics. We are entering a new era where satellites and robotic systems are merging, and America must embrace this change and excel at these advanced technologies.

For example, at Redwire Space we are developing systems such as Archinaut (also referred to as 'OSAM-2'), a satellite that, after deployment, will use robotics to build itself. In addition to robotic assembly, we are developing satellites that leverage 3D printing to create far larger objects in space than could have ever been placed into a rocket fairing. These space platforms that construct themselves after being deployed in space will offer substantially enhanced capabilities as well as resilience to attack that could never be achieved by traditional satellite systems. While Redwire Space has unparalleled heritage and expertise in this field, China is well aware of the importance of space-based robotics and has already deployed Shijian-17, a satellite with, among other features, a robotic arm that could be used to grapple satellites. Shijian-17 has already flown unusual orbital maneuvers bringing it closer to other satellites generating suspicion and concern. Again, the U.S. must bolster its efforts to equal and exceed Chinese space-based robotic capabilities to protect our industrial competitive edge as well as the nation's overall economy and security.

As noted previously, China's autocratic regime does have the benefit of policy consistency and the nation has focused on developing world-class space technology for decades.

China's efforts are coming to fruition and the U.S. faces an unprecedented challenge to maintain space supremacy or, in the long run, even parity.

The best and possibly only way for the U.S. to meet this existential threat is for America to embrace its great strengths that China struggles to or cannot reproduce. Specifically, the U.S. must redouble its efforts to leverage American entrepreneurialism. A free society, grounded in the rule of law, with a diverse population, will always innovate at a greater rate than more homogeneous nations where freedoms are severely curtailed. America created the commercial space revolution, and our private space sector is the envy of the world. Programs such as NASA's Commercial Orbital Transportation Services ("COTS") and the Commercial Resupply Services ("CRS") contracts, played a critical role in creating the commercial space industry as we know it today.

In order to effectively compete with China, the Congress, NASA, the Department of Defense, and the Intelligence Community, must all embrace public-private partnerships to an even greater degree than what is occurring today. The government must support commercial development, playing the role of both catalyst and customer for innovative technologies. Commercial space represents a force multiplier that has already transformed the nature of the industry. However, there is much more that can be done by the U.S. government to make efforts such as COTS and CRS the rule rather than the exception. Again, whenever possible, the government should serve as a customer for innovative capabilities that will maintain and accelerate U.S. leadership, particularly in critical areas such as orbital servicing, assembly, and manufacturing. Only by substantially expanding the use of public-private partnerships can the U.S. effectively protect itself and the world from emerging threats that will only become more pernicious in the years to come.

For all of these reasons, the NASA authorization bill should include explicit support to bolster Archinaut specifically and on-orbit servicing, assembly, and manufacturing technologies generally. This is a critical area of technological endeavor that the U.S. must excel in and explicit direction via an authorization bill is key to maintaining American competitiveness.

V. Establishing Norms of Behavior in Space

It is vital for America to lead not only in technology but in policy as well. As in any new frontier, establishing rules and norms of behavior will play a critical role in preventing conflict and ensuring that space is developed in a safe, sustainable, and peaceful fashion. While at NASA, it was my privilege to craft and negotiate the Artemis Accords which, in less than one year since their inception, have now been signed by twelve nations.

The Artemis Accords were successful due in no small part to the unprecedented partnership between NASA and the Department of State, and I want to take this opportunity to thank Jonathan Margolis, Acting Deputy Assistant Secretary for Science, Space, and Health at the Bureau of Oceans and International Environmental and Scientific Affairs for his support, partnership, and friendship in developing the Accords. I also need to thank another friend and colleague, Gabriel Swiney, the Department of State's lead civil space attorney who was one of

the first people I discussed the Accords with. Gabriel's vision and knowledge are reflected throughout the Accords and his skill made them a success. Finally, the Artemis Accords would of course not exist without the outstanding leadership of Jim Bridenstine, who provided strong and unflagging support for the Accords as well as the partnership with the Department of State, and the former Administrator simply wouldn't take no for an answer in his efforts to bring me to NASA.

The Artemis Accords present the model for future policy initiatives wherein NASA and State work in unison. Moreover, the Accords would not have succeeded without the coordination and assistance provided by the National Space Council, and its former Executive Secretary, Dr. Scott Pace. I have greatly benefited from Dr. Pace's support over the years, and his leadership was vital for both the Artemis Accords and the signing of the binding Gateway agreements, particularly the agreement with the Government of Japan. Finally, I want to again thank the Biden administration's leadership including Secretary of State Antony Blinken, National Security Advisor Jake Sullivan, NASA Administrator Bill Nelson, NASA Deputy Administrator Pam Melroy, and Senior Advisor to the Administrator, Bhavya Lal, for their strong support of the Artemis Accords. Again, continuity is vital, and I am personally grateful for the Biden team's robust support for building international partnerships and establishing norms of behavior in space.

Due to the Accords, the Artemis program has established the largest and most diverse human space exploration coalition in history, but much more remains to be done. Specifically, more countries should be added to the Accords and the Artemis program. For example, I hope that NASA and the Department of State continue and accelerate efforts that I worked on during my tenure at OIIR to bring African nations into the family of the Artemis Accords. I believe that the benefits of space exploration and space-based capabilities are particularly important for developing nations and that the unique views and voices of African youth in particular can greatly contribute to the Artemis program. Moreover, China has targeted Africa both economically and politically, and NASA should not cede African partnerships to rival nations. Additionally, it would be beneficial for a few more of our traditional space allies, specifically, France and Germany, to join the Accords demonstrating unified support in Europe for responsible norms of behavior in space. Finally, I hope that efforts at NASA and State are continuing for India to join the Accords. India's robust and growing space capabilities make their support for norms of behavior critical to achieve a peaceful and prosperous future in space for all of humanity to enjoy.

The Accords establish a strong foundation for beyond LEO civil space activities, building a future based on transparency, interoperability, the full and public release of scientific data, avoiding harmful interference, and environmental sustainability. However, new rules and norms need to be established for national security operations. The Tenets of Responsible Behavior in Space, described in a July 7th Memorandum by the Secretary of Defense, represents a good start. However, establishing an international coalition to support these tenets is vital to their success and universal adoption. The Artemis Accords serve as a model for how such coalitions can be built, and I know that myself and others who were involved in developing and implementing the Accords stand ready to assist our colleagues at the Department of Defense and Space Force in their own efforts to establish vital norms of behavior in the national security realm.

In addition to explicitly authorizing the Artemis program, I hope that the upcoming NASA authorization bill includes language complimenting NASA's work in support of the Artemis Accords, signaling to both partners and rivals that the Congress strongly endorses establishing global norms of behavior to ensure a peaceful and prosperous future in space.

VI. Collaborating and Competing with China

For better or worse, the U.S. – Chinese relationship will determine the future of space exploration and development. As described previously, the U.S. cannot afford to fall behind China in critical capabilities such as space-based robotics, in-space manufacturing, and space-based solar power. However, there are nontrivial opportunities to collaborate with China that could benefit both countries and advance global prospects for peace and prosperity.

Specifically, NASA and the Department of State should continue to advocate for China to sign the Artemis Accords. Although China is not a part of the Artemis program, and the Accords were written to ensure that nations participating in Artemis abide by international treaty obligations and norms of behavior such as the full, free, and timely release of scientific information, China signing the Accords would send a strong signal of unity and global consensus relative to the simple and intuitive principles of the Accords. The Accords were a product of lengthy negotiations between eight different space agencies and ministries of foreign affairs. The substance and text of the Accords represents the common ground among countries with a diverse set of policy positions (e.g., the U.S. opposes the Moon Agreement whereas Australia is a signatory). The Accords were written to be as inclusive as possible and, in particular, the United Arab Emirates officials who participated in the drafting process were a strong voice for ensuring that the Accords could be signed by any nation with a desire to support peaceful space operations and development. The Artemis Accords were explicitly and exquisitely crafted to unite nations with disparate views, bringing the world together to prevent conflict and ensure harmonious activities on the Moon and Mars. China committing to the Accords would be a welcome development that I believe would benefit both nations and global space policy discourse generally.

During discussions at the United Nations Committee on the Peaceful Uses of Outer Space, the State Department has invited China and all nations to sign the Artemis Accords. Beyond such interactions at the United Nations, I recommend that the State Department continue the practice of convening Civil Space Dialogues with China, to discuss the Accords and norms of behavior in space. If China were to join the Artemis Accords, like with other signatories, it would provide specific, actionable commitments that the country would be held to for civil space operations on the Moon, asteroids, comets, and Mars.

I have high hopes that a productive conversation could be held with China on norms of behavior due to my experiences with several global efforts that included Chinese participation. For example, prior to joining NASA, I served as an industry member of the Hague International Space Resources Governance Working Group, which brought together experts from around the world to draft 'building blocks' in support of establishing rules for space resource exploration

and utilization. One of China's leading law professors participated in the Hague Working Group and his input was robust, constructive, and productive. As a matter of fact, some of the text and ideas generated by the Hague Working Group were adopted as part of the Artemis Accords.

Moreover, I am currently supporting the efforts of the Global Expert Group on Sustainable Lunar Activities ("GEGSLA"), which is a NGO that, as the name indicates, is bringing together policy and legal experts from across the world to develop norms of behavior for the Moon. The GEGSLA involves many of the same academic, industry, and government experts as the Hague Group, including several Chinese nationals who have been working side-by-side with, among others, American commercial space leaders to establish rules of the road for lunar activities which are based upon not only the Outer Space Treaty of 1967, but the prior work done by the Hague Group and the Artemis Accords. While I know from personal experience that coming to agreement on even general principles for space exploration and development can be extremely difficult, I firmly believe that this is an area where the U.S. could and should engage with China in an attempt to identify common ground.

At the next Civil Space Dialogue between the U.S. and China, in addition to norms of behavior, other forms of collaboration could be discussed. For example, a swap of lunar samples would be a low-risk means of initiating cooperation in space with China, which NASA could engage in while staying well within the bounds of the Wolf Amendment. Finally, the U.S. is already collaborating with China and other nations on the Space Geodesy Project, which produces a wide variety of information for Earth observation and climate science. Additional collaborations with China on climate research is another area which, if handled correctly, could benefit both nations without running afoul of the requirements of the Wolf Amendment.

VII. Conclusion

Collaboration and cooperation must both be harnessed to ensure that humanity's journey into the undiscovered country of space is safe, peaceful, and prosperous. Again, we cannot afford to fall behind in critical new areas of space technology and must maintain the continuity of the Artemis program as well as maintain a continuous crewed presence in LEO. However, we must also reach out to both allies and rivals to collaborate whenever possible to support norms of behavior in space and mutual areas of scientific interest and concern such as climatology.

As mentioned previously, Redwire is a global leader for in-space manufacturing. We have an expertise in building microgravity products that will enable ambitious space exploration missions and improve life on Earth. Redwire, and all of us in the private sector, must join with our colleagues in government to build not just technology, but the future. This is an in-space manufacturing endeavor that will demand unprecedented work, coordination, and support from across industry and government. Although we will face many challenges, I remain confident in America's ability to build a new era in space of peace, freedom, and prosperity, benefiting the world and many future generations to come.