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**HEARING ON
SPACE SITUATIONAL AWARENESS, SPACE TRAFFIC MANAGEMENT, AND
ORBITAL DEBRIS: EXAMINING SOLUTIONS FOR EMERGING THREATS**

**BEFORE THE
COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION
UNITED STATES SENATE
SUBCOMMITTEE ON SPACE AND SCIENCE**

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Good morning, Chairman Hickenlooper and Ranking Member Lummis. Thank you for the invitation to return to the Subcommittee to talk about this important issue. Space debris and how we mitigate its potentially damaging effects on the space economy, our security, and our international partnerships was a top concern of mine while serving as the Director of the Office of Space Commerce at the Department of Commerce. It remains a top concern of mine now even in private life and within my new business and academic pursuits.

The Rise of the Space Economy

Let me start with the opportunity. There has been incredible progress in the space economy since I testified before this Subcommittee over two years ago, fueled by a world-class US space industry and a dynamic ecosystem of entrepreneurs, private finance and insurance, and other participants. US government agencies like NASA, NOAA, and the Department of Defense are shifting acquisition models to encourage and take advantage of commercial space developments, as well as space partnerships from London to Tokyo.

In short, the space economy is accelerating and diversifying. Technological breakthroughs in space-based communications are allowing competition with terrestrial fiber and facilitating competitive telephone and internet service where no fiber exists. Artificial intelligence is transforming a crush of satellite imagery data into useful economic information. More accessible and lower-cost launch opportunities combined with small satellite developments are allowing entrepreneurs to try new ideas and adapt them to quickly bring to market. An imminent wave of in-space servicing activities – inspection, refueling, and repair – will further improve the economics of space activities.

Back here on Earth, there's dramatic growth in private sector finance of space activities, including special purpose acquisition corporations (SPACs), as well as a range of entrepreneurial activities designed to disrupt traditional commercial space services or invent wholly new ones.

An even newer cluster of entrepreneurs is focused on training and caring for future space travelers as the United States, with bipartisan support and some of our allies, heads toward a permanent presence on the Moon.

Entrepreneurial activities are focused on improving on existing capabilities, like communications, remote sensing, and launch, while others are inventing new capabilities in areas like space manufacturing, space medicine, and edge computing and cybersecurity for space systems. Another cluster of entrepreneurial activities seeks to create the infrastructure for training, housing, and equipping the next wave of space travelers and to provide infrastructure for sustainable life and normal economic activity on the Moon. As we have marveled about private space travel over the past two weeks, commercially driven concepts like reusable launchers and satellite servicing will make space even more affordable and competitive.

Our understanding of the value of space is changing. Aside from our excitement about space travel, we are quickly moving from a general lack of awareness about the importance of space to a place where space is increasingly recognized as a key element of, if not *the* backbone of the 21st century economy. Space-based activities already contribute an estimated \$5 trillion in value to the US economy, and that number is growing.

Let me give you one key example. A recent on-line headline noted “all companies are space companies now!” Beyond the tremendous innovation we are seeing within the space community, we are also seeing non-space companies begin to experiment with their own ideas for leveraging space. Drawing upon “space as a service” business models, companies from many different economic sectors are designing new approaches for monitoring resources and increasing productivity, especially given developments in space-based remote sensing, Internet of Things (IoT) sensors and high-speed communications. We are at a point not unlike the advent of desktop computing in the late 1960’s and early 1970’s.

To say it another way, space is the platform that will fuel AgTech, CleanTech, EdTech, and other innovations, while deepening our understanding of developments on this planet and enabling exploration and habitation of outer space. Many States in our great Nation as well as many other countries are exploring how to leverage space for economic growth, talent development, and innovation.

The Challenge of Space Debris

These exciting space developments sometimes tempt us to think that all of this is automatic, that the conditions for success are locked in. Today’s discussion is about the immediate problem of space debris and the need for focused US government and private sector attention to the problem.

Let me provide a couple of examples: the April 2021 NASA and Space X launch of Astronauts to the ISS was flawless, save for a near miss with a hunk of space debris. It was the potentially deadliest sign of the urgency of dealing with the space debris problem. In late May, NASA and the Canadian Space Agency announced that a piece of space debris had punctured Canada’s

robotic arm aboard the International Space Station; the arm is used for transporting Astronauts during spacewalks and repair missions and for deploying scientific experiments.

Senators, nobody wins a game of “chicken” against space debris. These close calls are too close. Aside from the threat to human life, growing space clutter threatens US and allied investments in space as well as the growth of space commerce. Many of the growing commercial benefits I discussed earlier could be slowed or eliminated if, for example, operators have to add fuel or protective materials to avoid space junk. Business operations can be affected dramatically by a collision.

As this Committee knows, this is not a new problem, nor a partisan one. National policy discussions about this problem date back continuously through the Trump, Obama, Bush, and Clinton Administrations, with the first mention of space debris as a national policy matter dating back to the Reagan Administration. Long a discussion confined to the space community, space debris has gained widespread attention. Numerous US government and private organizations, including NASA’s Aerospace Safety Advisory Board, Secure World Foundation, the Space Safety Coalition, the Satellite Industry Association and others have highlighted the urgency of this very complex problem.

The Need to Advance Innovative Solutions

The space activities we are witnessing today are the pinnacle of American science and engineering, and the best of US government leadership and investment and the efficiency and creativity of the private sector. While space debris is a serious and immediate problem, there is no reason why we cannot leverage these same national capabilities to create effective new solutions and the birth of a new space safety industry.

There are at least four tools in our toolkit for mitigating the space debris problem:

- avoiding the creation of new debris
- improving our awareness of the space environment
- improving communications and warnings among all space operators, and
- active debris removal.

While US government investments in these areas vary greatly, there is a growing recognition of the roles that academia and the private sector can play in providing solutions. Commercial technologies for data management, analytics, and visualization that often apply in other disciplines need to be applied here, quickly, and commercial companies are developing new sensors and other unique tools to address this problem. I will say more on that below.

One of the complexities of the space debris problem is how rapidly it is changing. Launch operators CEOs like ULA’s Tory Bruno and Rocket Labs’ Peter Beck have expressed concern about launch window limitations because of space congestion, and hardly a week goes by without a prominent near miss between active satellites and debris, or between debris objects.

If we create solutions for 2021, they will also need to be pertinent to the space environment of 2025 and beyond. Continuous innovation will be needed to mitigate this challenging problem.

The Growing Role of the Private Sector

Space Policy Directive 3, Space Traffic Management (June 2018), recognized the urgency of the space debris problem and directed a whole of government approach to creating solutions. It recognized the need for investments in science and technology to improve our understanding of the space environment. It recognized the historic role of the Department of Defense in providing public space safety information, and the need to shift to a civil space traffic management model given growing security complexities in space and the rapid growth in commercial space activities. It recognized the critical importance of international partnerships in the interest of space safety and sustainability.

These aspects all speak to the importance of continuing US government roles in areas like research, governance, national security and foreign policy considerations, and our international obligations under the Outer Space Treaty. The strategic and economic importance of space assets demand constant focus on protection and freedom of action in space, which largely falls to the United States Space Force and US Space Command.

Space Policy Directive 3 also recognized the need to quickly modernize our national technical approach to improving space traffic management, mainly through improving space situational awareness. This was to be accomplished through creation of an open architecture data repository, where data, starting with DoD's "authoritative catalog" – information derived from classified sources but pertinent to space safety – could be managed, fused, analyzed, visualized, and disseminated in combination with a wide range of civil and commercial data sources. The repository was never seen as the ultimate goal, however: it was envisioned as a source of more timely and precise information for space operators, but also as a key source of information to inform new policies to promote space safety and sustainability.

Enter the private sector. As the value of space has grown, space operators and entrepreneurs have worked together to develop tools to mitigate risk to their systems and to promote continuing investment and innovation. Companies like ExoAnalytics, LeoLabs, and NorthStar Earth and Space have developed new and different ways to detect debris and other activities in multiple orbits; companies like COMSPOC, Slingshot Aerospace, and others are working to provide a continuously updated picture of the space environment for decision-making and channels for increased communications between space operators. Yet other companies are working on how to leverage autonomy, machine learning, and satellite beacons to confront this problem.

Beyond collision avoidance, companies are providing or planning advanced services for space operators like maneuver planning, orbit optimization, inspection, servicing, and even active debris removal. During a Department of Commerce industry day held last Fall, over 200

commercial firms provided ideas about how to quickly provide solutions to address the space debris and related challenges.

Common to all of these companies is their leverage of state-of-the-art cloud computing, communications, advanced analytics, and other advanced technologies, and a mindset of anticipating customer needs, continuous recapitalization of their capabilities, and innovation. These and many others are the early participants in an emerging space safety industry. Aside from the obvious space safety benefits, the open architecture approach will create new services in other domains like the space insurance industry, which will have more data against to assess risk for different constellations and orbits. This improved knowledge will create a climate of predictability to encourage continuing space investment and innovation.

Speaking of investment, private finance has played an outsized role in fueling the space economy. A June 2021 Space Angels report cites almost \$200B of private investment in over 1500 companies during the past decade. Financial institutions are taking a much more detailed look at the ingredients associated with a successful space company: the technology is only part of the story, equal in part to the management team, effective customer outreach, financial projections, and others. As the space economy grows, new financial mechanisms designed to support firms at all stages of growth are emerging, and space investment is increasingly accessible to individuals. Longer-term concepts like space banks and commodities exchanges are gaining attention as new ways to improving investor confidence.

The Changing International Landscape

We are not alone in our incredible space pursuits or in the need to deal with the space debris problem. It is a problem that all space-faring nations must consider.

The United States and its allies routinely discuss these issues in many different forums. NASA works alongside other global space agencies in the Inter-Agency Space Debris Coordination Committee; the Department of Defense considers them in the Schriever Wargame and in the Sprint Advanced Concept Training activities, which include commercial participants. During my time as Director of the Office of Space Commerce, we had routine and technical discussions about orbital debris with our Commonwealth partners, with the European Commission, European Space Agency, and the European Space Surveillance and Tracking Consortium, the Japanese Cabinet Office, and many others. The Space Enterprise Summit, co-hosted with State Department in Summer 2019, included representatives from many of these organizations and focused on the role of international government and business partnerships in addressing the problem.

Not everyone is on board, however. The uncontrolled reentry of a Chinese Long March 5B rocket in May (the second such occurrence) had the world guessing where it would land, whether it would harm people or damage property, and even whether the Chinese government cared about the recklessness implied by their space-faring behavior. Senator Mark Kelly expressed

surprise during a Senate hearing earlier this year that neither Russia nor China responds to notices of possible collision issued by the Department of Defense. Russia single-handedly held up progress at the United Nations on the Long-Term Sustainability Guidelines, a set of 21 internationally agreed technical, policy, regulatory and other measures for space safety, for a year until they passed in 2018 with global consensus. As a further sign of their unwillingness to cooperate, Moscow and Beijing have avoided signing the Artemis Accords while they pursue a separate, joint lunar base.

There is no doubt that if long-standing American leadership in space safety falters, these countries will step in. As the US and other governments work to establish new “rules of the road” for space – where we’re mostly starting from scratch – the private sector is likely to provide the first, practical examples of how to operate safely in space. However, the space component of Beijing’s Belt and Road Initiative is already designed to lock up emerging space partners, and increased involvement in space situational awareness and space traffic management will be no exception. Russian and Chinese proposals in this area are more government focused and less likely to welcome US commercial participation. They may also be exclusionary in other ways to US interests. The US and its allies need to ensure that emerging space countries have alternatives to the onerous terms of Chinese infrastructure deals, whether in space or on the ground.

In short, American leadership on space safety – which we have enjoyed for five decades – is at risk unless we avoid bureaucratic dawdling and fail to adequately resource a range of space safety and sustainability initiatives. The loss of leadership will have important strategic and economic consequences.

Role of the Commerce Department

I was asked to comment specifically on the role of the Commerce Department in this area. As the Committee may recall, the Office of Space Commerce was established over thirty years ago as the Executive Branch advocate for the U.S. commercial space industry. Advocacy can take many forms, such as highlighting emerging commercial investment and technology areas, encouraging greater US government leverage of commercial capabilities, helping break regulatory logjams for companies, identifying anti-competitive market behaviors abroad, and others. The Office routinely works with other Commerce Department organizations on issues like cybersecurity standards (NIST), space economic statistics (BEA), space weather and the commercial weather data pilot (NOAA), encouraging minority participation in space enterprise (MBDA), international advocacy for the US space industry (ITA), and others.

If the Committee agrees with my assertion that space is a key enabler of the 21st Century economy, I don’t know how we maintain our leadership and strategic advantage without a strong space and space commerce focus at the Commerce Department. That places a premium on having the Office interact regularly with Departmental leadership and with senior leaders throughout the rest of the Department.

Those who question the role of the Commerce Department in helping manage the space debris challenge, in concert with other federal agencies, fail to recognize the tremendous policy and technical contributions of NOAA – which ensures the safe passage of exquisite weather and research satellites every minute of every day and manages the Nation’s space weather program – but also the National Institutes of Standards and Technology, the National Telecommunications and Information Administration, and otherwise brings highly relevant experience to oversight, regulation and industry relations. The Congressionally-directed National Academy of Public Administration study on Space Traffic Management published in August 2020 strongly endorsed the roles of the Commerce Department and the Office of Space Commerce in managing a collaborative network of U.S. government, industry, and international partners against the challenges of orbital debris. And to provide best practices and evaluate standards for encouraging responsible behavior in space.

It is my opinion that both the advocacy and the space debris missions are so important that the Office cannot successfully achieve them from deep within NOAA. The Office should be elevated to the Office of the Secretary, (returned to its original home, actually) and provided funding consistent with the magnitude and importance of these tasks. Further, sufficient resources should be provided to the Commerce Department and other federal Agencies consistent with the urgency of the overall space debris challenge and its consequences, as I have described above. As necessary, funding should be directed to maximum commercial purposes of data, analytics and other services within the open architecture context described above.

Academia’s role is also growing in importance, given the great complexity of the orbital debris problem and its rate of change. Since departing Commerce, I have been participated in the activities of MIT’s Space Enabled Group, led by Dr. Danielle Wood and affiliated with MIT’s Media Lab. Space Enabled has been part of an academic-industry project sponsored by the World Economic Forum to develop a Space Sustainability Rating for industry to assess, on a voluntary basis, factors such as the choice of orbital altitude and the ability of systems to be detected and identified from the ground. Professor Moriba Jah’s work at the University of Texas on AstriaGraph – another system designed to track specific objects in space, is another example of pioneering work worthy of expansion and adoption into a scientifically rigorous and open architecture approach to space safety.

Finally, Senators, many of the themes I have mentioned in this last section of my prepared statement are consistent with the Space Preservation and Conjunction Emergency (SPACE) Act of 2020, as initially introduced by Senator Wicker and Senator Cantwell and reintroduced with strong bipartisan support in 2021. I’m thankful to this Committee for recognizing the importance of this topic and for the bipartisan efforts to pass this legislation. Among the many important provisions of this legislation are the proposal for creating a Center or perhaps Centers of Excellence for SSA, ideally at an institution of higher education. In concert with the other provisions, this reflects the need for substantial academic scientific, technical, policy, and economic research associated with a civil SSA and space traffic management system.

I thank the Committee for your time and your consideration of these important issues.