Statement of

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I want to start by expressing my thanks to Chairwoman Horn, Ranking Member Babin, to the members of the subcommittee and the full committee for the opportunity to testify today. It is a pleasure for me to speak before you today. All of us have the privilege and great responsibility to live in a time during which the global community in general and the United States in particular have the opportunity to make decisions that can lay a foundation for a sustainable space environment for years to come. Making space sustainable would mean that we make sure it is a safely environment to perform commercial, academic, scientific and security missions without undo risk of harm due to human-create risks such as satellite collisions.

Let us reflect on why we are here. Why is it valuable for us to set aside this time to speak about Space Situational Awareness and Space Sustainability?

In one sense, we are here because human activity in space brings tremendous social, economic, environmental and cultural value on earth. I lead a Research Group called Space Enabled at the MIT Media Lab. Our mission statement in the group is that we seek to advance justice in earth's complex systems using designs enabled by space. This simply means that we want to consider all the ways that space technology, science and innovation can support healthy, thriving communities on earth. If you would like to hear more examples about this, you can watch my TED talk which is called "Six Space Technologies We can Use to Improve Life on Earth."[i] In the TED Talk, I share examples of satellite earth observation being used to understand the growth of crops. I talk about using satellite communication systems during times of disaster to ensure relief workers can communicate and using satellite communications to connect doctors to distant patients. In the talk, I show the use of satellite-based positioning systems for tracking wildlife. Many of us also enjoy the benefits of satellite positioning when we order a ride share or navigate a new city. My talk also argues that microgravity research and human space flight benefit society broadly when we transfer

knowledge of how the human body, plants and animals adapt to the space environment to rethink products, health care, exercise, manufacturing and food production on earth. I remind us in the talk that there are hundreds of spinoff technologies from NASA alone, and meanwhile NASA's sister agencies around the world also produce their own examples of capabilities designed for space and moved into other sectors via patents, publications or the movement of people. Finally, I argue in the TED talk that fundamental space research, such as astrophysics and the study of the Sun's impact on the earth in the form of space weather, brings both long-term and short-term benefits to society. As we slowly unlock deep research questions around planets that orbit other stars, the behavior of water on planets throughout our solar system, and the evolution of distant galaxies, we are also training engineers, computer scientists, data scientists and technicians. I often celebrate the Square Kilometer Array[ii] project that will create the largest radio telescope in the world located in both the continents of Africa and Australia. Many new engineers, scientists, hotel managers, telecommunication network specialists and communications experts will emerge from this project.

Human activity in space provides us with useful services and inputs to our global economy. Recently, I was honored to be invited by the American Institute of Aeronautics and Astronautics to give a keynote speech on the first day of their annual SciTech Forum[iii]. The theme of the event was "Driving Aerospace Solutions for Global Challenges" and the theme the organizers asked me to address was "Using Space to Support a Sustainable Society."[iv] I greatly admired the organizers of the event because they showed true leadership in our aerospace community by selecting these themes. The aerospace industry does have a key role to contribute to ensuring that we move toward meeting global challenges such as climate change, global economic inequality, the changing nature of work, human migration, natural disasters, economic uncertainty and global public health. Space is also the perfect vantage point from which we can watch our special home planet of Earth, to understand how it is changing and what our global cycle of production and consumption is doing to it. I used to work for NASA's Earth Science[v] team at the Goddard Space Flight Center in Greenbelt Maryland. I will always be an advocate for the excellent work of NASA's fleet of earth observation satellites[vi] that capture both images and measurements of the state of the oceans, land, atmosphere and glaciers. From this satellite-based perspective, it is clear that our civilization is facing several, interrelated crises of sustainability. I invite us to see this as one crisis or one opportunity for sustainability that spans our oceans, our land, our atmosphere and Earth's orbit. In each of these zones, our human economic activities of consumption and product have deposited unmanaged populations of waste. We dump waste carbon dioxide into our atmosphere, waste plastics into our oceans and waste objects from launch vehicles and retired satellites in Earth's orbit. The behavior follows similar patterns in each zone. Our civilization has the opportunity right now to review how we will manage this waste and create a sustainable future for our children and their children.

Another reason we are here is that space is one of the domains that carries a paradox. It is at once both highly open and welcoming to everyone and at the same time it is exclusive and strongly influenced by a few countries. During the first week of February 2020, I presented at the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space. This is the United Nations committee that curated the five seminal space treaties that govern international space law, including the Outer Space Treaty which states in Article I, "The

exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all [hu]mankind." In many ways this principle is true. I spent the much of the past 15 years performing academic research about the applications of space used in Africa, Latin America and Southeast Asia and studying the many countries in these regions that are starting and expanding national space programs.[vii] Dozens of countries in every region of the world have completed national satellite projects and trained local engineers in satellite design and operations. Every country hosts teams and offices responsible for ensuring that they can participate in space communication infrastructure and apply satellite earth observation data for creating strategic maps that inform environmental management. Today, as countries participate in small satellite projects, microgravity research projects in the International Space Station and space entrepreneurship, the global space community is constantly growing. Thus, every country on earth is a space country. However, this does not mean that all countries enjoy equal access to the benefits of space.

The countries that have been the most active in pursuing human activity in space, including the United States, are also the countries that have created the most risk for future space operations being unsustainable. This is why we must come together to talk about Space Situational Awareness. In the short term, SSA may mean asking whether today's satellite are safely avoiding colliding with one another or with existing debris. In the long term, an integrated approach to Space Situational Awareness also means asking what are the trends for where objects are located in space? What are the impacts of currently crowded orbits for the risk of future satellite missions in those orbits? What is the demand from industry to use specific orbital regimes and what is driving that demand? Who are the new government, commercial and academic players who seek to participate in space activity and what are their needs? What are the sustainable options for expanding space activity given the existing set of waste that is already orbiting the earth?

When I was an undergraduate studying aerospace engineering at MIT, trying to learn how to build a satellite, I never considered that a potential design constraint on a new space mission is whether there is enough room in space for my mission to operate safely. Now, as we all sit here and imagine a satellite orbiting around earth, we might say, of course there is enough room. Space is Big! But this does not take into account the key technical challenges of Space Situational Awareness. Space may be big, but it is technically very difficult to detect, track and identify all the objects that orbit the earth, especially the small objects that are the results of collisions or break ups for which we know little about their shape and make up. Space may be big, but there are a few key locations that many satellite operators prefer to operate. Space may be big, but satellite collisions are low probability, high consequence events that have an impact far beyond the owners of the specific satellites. Due to these concerns, it is necessary to start teaching engineering students that they should consider methods to reduce the risk of collisions as part of their regular space mission design activities.

The global space community is working on many fronts to both identify methods to improve Space Situational Awareness and identify actions that satellite operators can take to reduce the likelihood that they will cause a collision or long-term debris. The United Nations Committee on the Peaceful

Uses of Outer Space Adopted the 21 Guidelines for the Long-term Sustainability of Outer Space Activities[viii]. These provide a starting point to recommend decisions that regulators and satellite operators can take to reduce their own contributions to debris.

As we look around the world, there is not a uniform regulatory regime or code of behavior that all types of satellite operators are following regarding contributing to Space Situational Awareness knowledge or reducing the risk of space debris. This is understandable given the historical development of space activity within countries. Because of this global diversity, there is an opportunity for a non-government approach to complement formal international instruments, national regulation and industry initiatives. The complementary approach can be a positive incentive that rewards any satellite operator, government, commercial or academic, who takes proactive measures to contribute to space sustainability. I part of a team that is creating such a positive incentive; it is called the Space Sustainability Rating.[ix]

The Space Sustainability Rating was conceived by the World Economic Forum's Global Future Council on Space[x] in response to the planned operation of many new commercial satellite constellations in Low Earth Orbit. The World Economic Forum saw an opportunity to encourage each satellite operator to consider how they could behave in a responsible manner with their satellites as the number of missions in LEO is expected to drastically increase. The World Economic Forum held a competitive solicitation process to request teams to volunteer to create the Space Sustainability Rating. I was selected to co-lead the team creating the rating. The organizations involved include the World Economic Forum, the European Space Agency, Bryce Space and Technology, the University of Texas at Austin and my institution, the Massachusetts Institute of Technology. The SSR will be a score that any satellite operator can apply to receive. The score considers two key factors. First, the score asks where a satellite mission plans to operate and what the current state of that orbital regime is based on past satellite operations. In other words, the SSR asks whether Earth orbit has the capacity for a new mission to join the satellites and debris that are already in a specific altitude and inclination. Second, the SSR asks what the satellite operator will do to increase their Space Situational Awareness of their own mission, to decrease the time their satellite spends on orbit after the mission is complete and to coordinate effectively with other space operators in order to avoid collisions. Our team is still in the process of designing the Space Sustainability Rating and deciding how it will function operationally. Our hope it that it will become a routine process for space operators of all types, from universities, firms and governments, to apply for an Space Sustainability Rating during the design phase of their mission and to use the information to help them select responsible behaviors. They can continue to apply for the SSR throughout the life of their mission as their mission plans evolve and impact their level of sustainability. In order to make the SSR relevant around the world our team is pursuing regular outreach to government, academic and civil society audiences. We are receiving input via workshops and meetings from satellite operators, launch providers, government regulators and universities. We hope that governments will join us in promoting this methodology as a way to recognize responsible behavior in space.

Our planet does not yet have a Space Traffic Management system that directs how satellites are operated and give requirements on physical maneuvers for space operators. There is ongoing

dialog at the international space community that now is likely the right time to start global dialog about how to set up a Space Traffic Management system. In anticipation of this, my research team performed a study to consider the interests of countries that are new to space in the way a future Space Traffic Management System might work. The findings of our research showed that countries from all regions, including Latin America, Africa, Southeast Asia and Eastern Europe, expressed great interest in contributing to the design of a global Space Traffic Management System and they hope the process is done in a forum that allows them to share their concerns openly.[xi] The United States clearly plays a leadership role in space for all over countries in the world. This is both a privilege and a responsibility. It means that the US has the responsibility to consider how to achieve national goals while also helping to lay a foundation for global Space Traffic Management regimes that will be beneficial to countries from many backgrounds. It will be beneficial to the United States if we build strong international relationships among emerging space countries by finding common vision with them for how to design and implement a global Space Traffic Management system.

An excellent example of the opportunities of engaging with countries of all backgrounds in space is the case of Bermuda. The small island of Bermuda is well known for hosting a dynaics re-insurance industry and for maintaining beautiful natural settings that attract tourists. The current government of Bermuda seeks to further diversify their portfolio of economic focus areas. They are asking how space will continue to grow in the future as one of their national priorities. Bermuda already participates in the global space community; they host tracking stations that support launch and satellite tracking facilities for NASA and other space organizations. I serve as an advisor on the Space and Satellite Advisory Panel to the Government of Bermuda. Bermuda is developing a national space strategy and keeping Space Sustainability as a key theme in their plans. Countries like Bermuda want to continue benefiting from the services and spinoffs of space. They also want to directly participate in the dialog about how the global community will ensure sustainable space operations for years to come. Bermuda is not alone. I am honored to visit countries regularly in Africa and Latin America who see participation in the global space marketplace as core to their national vision. I have had discussions like this recently in countries such as Colombia, Chile and Angola.

Thanks to historical leadership, the United States has a special role to play in response to the integrated crisis and opportunity of global sustainability on land, in the ocean, in the atmosphere and in space. We do not have adequate Space Situational Awareness to ensure safe operations of space missions for years to come; thus, we must continue to innovate and collaborate to improve the outcomes in this field. The US can also choose to serve as a productive global leader in the dialog on Space Traffic Management. I recommend several policy actions that can help address these challenges.

1) **Commitment to Space Sustainability:** The US government should adopt a commitment to space sustainability as a principle driving space activities. Space Sustainability means ensuring that space is a safe environment for future operations of human space flight, scientific missions, commercial missions and missions by emerging space actors.

2) **Continued engagement in International Dialog Space Policy Forums.** The US government should continue to engage deeply in international space policy forums such as the Committee on the Peaceful Use of Outer Space and the Interagency Space Debris Coordination Committee.[xii] The US should look for ways to build common vision with emerging space nations who are interested in space sustainability
3) **Provide government support for SSA and STM work.** The US government should ensure that adequate funding and mandates are allocated to allow robust academic research and operational activity to improve Space Situational Awareness and develop concepts related to Space Traffic Management.

Thank you for your time and I look forward to our dialog today.

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[i] https://www.ted.com/talks/danielle_wood_6_space_technologies_we_can_use_to_improve_life_on_earth?language=en

[ii] https://www.skatelescope.org/

[iii] https://www.aiaa.org/SciTech

[iv] https://www.media.mit.edu/events/wood-at-2020-aiaa-scitech-forum/

[v] https://science.nasa.gov/earth-science

[vi] https://svs.gsfc.nasa.gov/4772

[vii] Wood, D. & A. Weigel, "Architectures of Small Satellite Programs in Developing Countries," Acta Astronautica, Vol 97, April – May 2014, pp 109-121. https://doi.org/10.1016/j.actaastro.2013.12.015
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[viii] https://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html

[ix] https://www.media.mit.edu/posts/creating-a-space-sustainability-rating/

[x] https://www.weforum.org/communities/the-future-of-space-technologies

[xi] Lifson M and Danielle Wood, "Implications of Emerging Space Nation Stakeholder Preferences for Future Space Traffic Management Archtiecture," Proceedings of the International Astronautical Congress, Washington DC, October 2019.

[xii] https://www.iadc-home.org/