**Written Statement of**

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**Subcommittee on Space and Aeronautics**
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**"Space Situational Awareness: Guiding the Transition to a Civil Capability"**
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Chairman Beyer, Ranking Member Babin, and distinguished members of the subcommittee, I want to thank you for the opportunity to speak to you today on this important topic. As of January 2022, there were nearly 5,000 operational satellites in Earth's orbit. This number has more than doubled since January 2020 and is expected to continue growing rapidly.[1] Space assets are critical to the global and U.S. economy as well as U.S. national security. These operational systems are surrounded by tens of thousands of pieces of debris larger than a softball (10 centimeters) – large enough to destroy a spacecraft in the event of a collision.

One of the most fundamental missions for ensuring the safety, security, and sustainability of space is Space Situational Awareness (SSA). SSA involves tracking objects in space, predicting their future location, and assessing the likelihood of possible collisions. Right now, the U.S. Department of Defense operates the most advanced SSA system in the world. They collect data from a wide array of sensors and fuse that data to create a catalog of space objects. They also conduct analysis that allows them to predict the future location of these objects and provide advanced warning of potential collisions (referred to as conjunctions). The basic version of the space catalog as well as the conjunction warnings are made available free of charge to all satellite operators around the world.

With the rapid growth of activity in space – particularly commercial activity – there has been a recognition that some components of the Space Situational Awareness mission should be transitioned to a civil agency. Space Policy Directive 3 stated that the Department of Commerce should take on this mission, and a follow-up report conducted by the National Academy of Public Administration reenforced the importance of this transition. The U.S. and international space community has been enthusiastic about this effort.

However, there are still a number of important decisions to be made in relation to this transition. In my testimony, I will focus on five key questions that need to be addressed:

[1] Union of Concerned Scientists. Satellite Database. 1 October 2019.
Union of Concerned Scientists. Satellite Database. 1 January 2022.
https://www.ucsusa.org/resources/satellite-database

1. Mission Definition: Which elements of the SSA mission should be taken on by a civil agency?
2. Commercial Engagement: How should the civil agency engage with the commercial sector?
3. Quality of the Free Products: What quality of product should be provided by the civil agency free of charge?
4. International Engagement: How should the civil agency engage with the international community?
5. Preparation for the Future: How will this transition affect future developments in space, including space traffic coordination and management?

**1. Which elements of the SSA mission should be taken on by a civil agency?**

As mentioned above, there are many tasks associated with conducting space traffic management. Data needs to be collected by a series of sensors. That data needs to be fused to generate an understanding of where objects are located in space. This information is used to create and maintain a catalog of space objects. The data is also analyzed to determine which objects may collide in the future and calculate the likelihood of each potential collision. Finally, warnings based on this analysis are provided to satellite operators to inform their actions.

It is likely that the DoD will continue to conduct the core elements of this mission – data collection, fusion, and analysis – regardless of the activities of a civil agency, because Space Situation Awareness – or Space Domain Awareness, as the military refers to it – remains central to the national security mission. The DoD must monitor objects in space to conduct threat assessment and enable attribution. The DoD will also have requirements for intelligence information and other specialized data particularly suited to those national security missions. It would be useful for the United States to conduct a thorough analysis of the long-term vision and requirements for the military Space Domain Awareness capability. This would provide a clear understanding of exactly which elements of the system must be retained by the military long-term.

A civil agency would, at the least, be expected to take on the task of liaising with commercial and international space operators around the world: providing the catalog of space objects and conjunction warnings. The civil agency should be the main point of contact and prime interface for U.S. SSA capabilities for the world.

However, there are also benefits to having a civil agency also undertake its own analysis – generating its own catalog of space objects, separate from that created by the DoD – as well as generating its own conjunction warnings. A civil agency could even bring in its own raw data – perhaps through a combination of civil and commercial sensors, adding to any data it receives from DoD sensors. In determining which portions of the SSA mission a civil agency should engage in, the core tradeoff is between redundancy and openness.

The drawbacks of redundancy are relatively straightforward: if two U.S. agencies are conducting very similar missions, this increases the total cost to the U.S. government. Also, to the extent there is overlap in the missions or activities of the military and civil agencies, care should be taken to ensure their findings are aligned. It would be undesirable to have a situation in which

two U.S. agencies do not agree on the location of an object or the likelihood of a collision, even if the DoD predictions are no longer released publicly. Close coordination between the two agencies would be needed to ensure that this does not occur.

The benefits of giving a civil agency a larger portion of the SSA mission stem from the fact that a civil agency can be much more open and transparent in its operations than the military. This openness enables the United States to better engage with commercial and international partners, as well as the research community – goals at the heart of undertaking this transition.

While the U.S. military provides an important global service through its current provision of the space catalog and conjunction warnings, it provides very limited transparency into its processes for developing these products. The catalog consists of relatively simplistic "two-line element" data not sufficient for use in independent conjunction analyses. It does not provide access to raw data, covariance information, or algorithms underlying its analysis. While this is perhaps understandable for a national security entity, it has been a source of frustration for commercial and international partners.[2] Without this type of information, these actors have no way to independently verify the information they receive from the United States or compare it to results they receive from other systems.

When the United States is not able or willing to provide sufficient transparency from their space information systems, other nations are incentivized to develop their own independent systems, and this can erode U.S. influence and leadership. This mechanism is already at play in the SSA sector to some degree.[3] There has been an increase in the development of SSA capabilities across both international and commercial entities in recent years, with nations and regions creating SSA systems independent from the United States.[4]

By contrast, if a civil agency conducts its own analysis, independent from the U.S. military, this entity will be better able to share data and algorithms used to develop SSA products and services. This openness will facilitate trust and encourage international partners and commercial satellite operators to rely on U.S. data, maintaining U.S. influence and leadership in this area. This would also allow the United States to collaborate more closely with nations that choose to develop their own independent systems, ensuring that these developments contribute to, or at least align with, U.S. efforts. This type of cooperative engagement can increase the quality and resilience of the U.S. SSA capability.[5]

Openness also facilitates engagement with the commercial and research communities. On this topic, we can draw some useful analogies to the Earth observations and weather communities. In the early 2000s, analyses showed that the U.S. had a much larger commercial weather sector than Europe, due in part to the U.S. adoption of open data policies. Entrepreneurs were able to build

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[2] Lal, Bahvya, Asha Balakrishnan, Becaja M. Caldwell, Reina S. Buenconsejo, and Sara A. Carioscia. "Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM) IDA 2018 SSA Report." Institute for Defense Analysis. Science & Technology Policy Institute. April 2018.
[3] Borowitz, Mariel. "An Interoperable Information Umbrella." *Strategic Studies Quarterly* 15.1 (2021): 116-132.
[4] Borowitz, Mariel. "Examining the Growth of the Global Space Situational Awareness Sector: A Network Analysis Approach." *Space Policy* 59 (2022): 101444.
[5] Borowitz, Mariel. "An Interoperable Information Umbrella." *Strategic Studies Quarterly* 15.1 (2021): 116-132.

on the government's basic data product to create new and innovative products and services.[6] Similarly, researchers with access to satellite data and government models could experiment easily and generate new knowledge. The resulting partnerships between government, commercial, and academic weather communities have helped the U.S. to remain a global leader in this area.[7] These effects are relevant to the SSA sector, as well. Access to SSA data and algorithms can allow entrepreneurs to develop new products and allow researchers improve U.S. approaches to analyzing and predicting the location of space objects, ultimately improving the quality of space situational awareness as a whole.

It is of course important to consider the national security implications of sharing SSA data and algorithms. However, as others have pointed out, given the rise of independent national and commercial systems, the U.S. does not have a global monopoly on SSA information. Even if the United States chooses not to share its data and algorithms, actors have an increasing number of other sources from which they can procure this information.[8] In addition, if the U.S. has both military and civil components of its SSA system, the civil agency could adopt an open data and open science model that promotes sharing and engagement, while the military retained its classified approach. The U.S. military would benefit from the innovation in the civil sector without revealing its own raw sensor data or algorithms.

**2. How should the civil agency engage with the commercial sector?**

As noted in the previous section, transitioning the SSA mission to a civil agency will make it easier for the government to engage with the commercial sector. However, the government still has decisions to make about how to structure this engagement: which functions, products, or services are inherently government missions, and which should be left to the commercial sector? What types of engagement, support, or public private partnerships can allow the United States to best leverage and promote the commercial SSA sector?

Commercial SSA activity has grown rapidly in the last five to ten years. A decade ago, there was relatively little commercial SSA activity, and today there are companies offering services that in some cases rival those offered by the U.S. government. Given the increasing capability of commercial entities – most of which are in the United States – it is important to consider which tasks should be undertaken by the government and which can and should be left to commercial entities. In making this decision, it's important to consider ethical responsibilities, national interest, and practical limitations to government activity.

The conjunction warnings produced as part of the SSA mission play an important role in ensuring the safety of space objects and the long-term sustainability of the space environment. Because of this safety role, particularly when human activity in space is involved, it could be argued that the United States has an ethical responsibility to provide data, even if commercial entities could conceivably make a profit by selling this product. An analogy can be drawn to the

[6] Pira International and European Commission. Information Society DG., Commercial Exploitation of Europe's Public Sector Information: Executive Summary (Office for Official Publications of the European Communities, 2000).
[7] Borowitz, Mariel. *Open space: The global effort for open access to environmental satellite data*. MIT Press, 2017.
[8] Borowitz, Mariel. "Strategic implications of the proliferation of space situational awareness technology and information: lessons learned from the remote sensing sector." *Space Policy* 47 (2019): 18-27.

weather sector. The commercial weather industry is capable of generating tornado warnings and could conceivably sell access to these warnings. However, there is an ethical responsibility on the part of the government to ensure that citizens have access to this critical safety information free of charge. There are also benefits to ensuring there is one authoritative, trusted source for severe weather watches and warnings, rather than having many individual commercial entities release potentially conflicting guidance.

Sharing high-quality conjunction warnings is also in the U.S. national interest. Of the nearly 5,000 objects in space, more than half are affiliated with the United States.[9] While all nations rely on space assets to some extent, the United States is the most reliant on space objects for its economy and national security. Given this situation, it is in the U.S. national interest to avoid collisions among space objects to ensure the long-term sustainability in the space domain. To achieve this, it is also in the U.S. interest to ensure all space operators have access to the high-quality SSA information necessary to avoid collisions in space. Providing this information free of charge is the best way to maximize the use of this data and doing so requires government action.

In addition to continuing to provide high-quality conjunction warnings free of user fees, the United States government should also consider making raw or minimally processed data as well as high-quality space catalog data available free of charge. Currently, this type of data is not made available by the United States, since the current SSA sensors are operated by the U.S. military. However, as noted above, if civil sensors are developed, it may be possible to share data more transparently, facilitating engagement with the international, private, and academic sectors, and maximizing the socioeconomic benefits of this data. With respect to terrestrial environmental information, the National Oceanic and Atmospheric Administration (NOAA) Policy on Partnerships states that "government information is a valuable national resource, and the benefits to society are maximized when government information is available in a timely and equitable manner to all." Based on this, NOAA's policy is to provide "open and unrestricted access to publicly-funded observations, analyses, model results, forecasts, and related information products."[10] A similar policy would be appropriate for civil SSA data.

Even if the government identifies the above missions as inherently government functions, there are many opportunities for commercial entities. While the United States can and should provide information relevant to a broad community, it will not be practical to provide tailored products to individual customers. Again, there is an analogy to weather: the National Weather Service does not provide tailored weather forecasts for individual ski resorts or off-shore oil platforms – these services must be procured from the private sector. Similarly, satellite operators interested in tasking sensors to get in-depth analysis of a potential conjunction or other issues relevant to their spacecraft or constellation should turn to private SSA providers which will allow the SSA industry in the United States to flourish.

The government may also engage the commercial sector in the purchase of raw sensor data to be ingested into the civil government SSA analyses, assuming the data meets requirements for

[9] Union of Concerned Scientists. Satellite Database. 1 January 2022.
[10] National Oceanic and Atmospheric Administration. "Policy on Partnerships in the Provision of Environmental Information." NAO 216-112. 19 January 2006. https://www.noaa.gov/work-with-us/partnership-policy

quality and reliability. This type of partnership can be more complicated, as the government must determine whether this data, like civil government data, will be shared freely with international partners and/or the public. Open sharing has many benefits, as listed above, but it makes it difficult for commercial entities to sell that data to any additional customers. NOAA is facing similar challenges in considering commercial data buys for its terrestrial weather system.

However, there are ways to overcome these challenges. One option is to purchase commercial data under an open license that sufficiently compensates the commercial entity for the impact on data sales to other customers. While more expensive, this would allow the U.S. to benefit from commercial innovation and efficiency while also promoting openness. Commercial entities could still sell value-added products and other special services. Another option is to use commercial data in data products – such as the space object catalog and conjunction warnings – which are provided for free, without releasing the underlying data. Unlike in the global weather community, there is not currently an expectation for full and open sharing of SSA sensor data. A civil entity could choose to share raw or minimally processed data from its own sensors while refraining from releasing commercial or military SSA data. The civil entity would still benefit from using all of this data in the generation of the space object catalog and the conjunction analyses, and these data products could be shared freely without compromising proprietary or classified information.

**3. What quality of product should be provided by the civil agency free of charge?**
Closely related to the debate on the role of the government versus commercial entities is the question of how to determine what level of quality the government should provide in its free products. As noted above, the U.S. government currently provides a space object catalog as well as conjunction warnings, and a civil government would presumably continue to do this.

Conjunction warnings are arguably the most important SSA product released by the United States, due to their direct impact on satellite operator decision making. Given the U.S. national interest in avoiding collisions, it is in the U.S. interest to ensure spacecraft operators have the best available information when making decisions about whether and how to maneuver their spacecraft to avoid a collision. This suggests that the government should seek to provide a high-quality product: one that is timely, precise, and accurate. If, for example, the United States was aware that a collision between space objects was likely, it would surely want to provide that information to the operators involved, rather than hoping those operators would procure adequate information from the private sector or another source. To return to a weather example, the United States strives to ensure that all people have access to weather information – particularly severe weather warnings and watches – and thus provides high-quality information free of charge.

However, while the United States desires that space actors have access to the highest quality information possible, there will be practical limitations – conjunction warnings will never be perfect, and the government must trade off efforts to improve these products with investments needed elsewhere. For this reason, the U.S. should, at a minimum, ensure that its product is *actionable*. This means that it is of sufficient quality that most satellite operators will trust the warning and be willing and able to make decisions based on it.

Once again, a weather analogy is helpful. The United States government provides tornado warnings. The most important aspect of these warnings is ensuring that they are clear and accurate enough that people will actually heed them. As I've seen in my own experience growing up in Minnesota, if false warnings occur too frequently, instead of heading down into the basement, people look at their weather app or check the weather radar, and often just continue on with their day.

There are many reports that we're already starting to see this type of behavior among spacecraft operators. Due to the rapidly growing number of objects in space, operators are receiving significantly more conjunction warnings. For some, it has become impractical to maneuver – or in some cases even investigate – each of these warnings. Lack of trust in the data also detracts from the willingness of operators to take action. When spacecraft operators do not find these warnings actionable, they no longer have value.

In order to ensure the freely provided conjunction warnings are actionable, the U.S. government will have to work closely with both operators and the research community – something a civil agency will be well-suited to do. Operators can help the U.S. government understand what would be required to build the trust and quality necessary to ensure they take action. The research community can help to make the improvements in the system necessary to meet these requirements. It is worth noting that this type of work requires both physical and social sciences. As demonstrated in the weather community, the impact of warnings is not just about the quality of the data and analysis, but also but the ability to communicate this information in a way that users understand and know how to respond to. We should keep in mind that satellite operators include not only large, experienced firms, but increasingly include new space actors from emerging space nations, start-up companies, universities, and even high schools.

Further, this product cannot remain static over time. Just as the space environment is changing and risks are increasing, in order to remain relevant – and actionable – the quality of the conjunction warnings must improve, as well.

With respect to the space object catalog, as well as any future civil SSA sensor data, we should think about the impact of data quality on the commercial and research communities. Data is a key building block generating new knowledge and strengthening our economy. When entrepreneurs and researchers have access to high-quality information, they find innovative ways to build new value-added products and grow the U.S. space industry and to improve our understanding of the space environment. Right now, the space object catalog provides relatively simplistic two-line element data for space objects. Basic information on space objects, such as object mass and size, is often missing. By improving the quality and scope of the information made publicly available, the U.S. government could create more opportunities for meaningful research and innovation.

**4. How should the civil agency engage with the international community?**

The United States is currently a global leader in space situational awareness. The United States operates the most advanced SSA system in the world, and it is the only one that makes data and services available to all users around the world, free of charge. Leadership in this area benefits the United States in practical ways – helping to avoid collisions and ensure sustainability of the

space environment – and it provides opportunities for the United States to demonstrate its commitment to peaceful engagement with nations around the world. The U.S. can and should continue to lead in this area.

Just as a civil agency will be able to open new avenues for cooperation with the commercial sector, a civil agency will be well-suited to engage international partners as well. The DoD has already begun this process through its Space Situational Awareness Data Sharing Agreements, but the civil agency can expand these partnerships both in terms of the nations involved and the opportunities for engagement and data exchange with each partner.

International activity in space situational awareness has been expanding significantly, and the United States can benefit from access to the data and analyses conducted by other nations. Close engagement can improve the quality of the U.S. SSA system. It can also help the United States to build agreement among nations and harmonize differences among systems.[11]

While the United States accounts for a large portion of activity in space, activities in this environment are inherently international – many countries share this environment and must work together to ensure it remains safe and sustainable. The United States benefits from having a system that is perceived by the global community to be accurate and reliable. Helping to harmonize the U.S. understanding of activity in space with that of other nations will be increasingly important.[12]

There are multiple different national and regional SSA systems, each using different data, relying on different algorithms, and generating different results. In some ways these differences can provide value – taking multiple approaches to solving the same problem helps improve certainty that the solution is accurate. By contrast – if we are generating significantly different findings – different understandings of where things are in space and where they're going – this is a problem. In this case, nations will have different understandings of when a collision is likely, based on which data provider they use. Nations may differ in their assessment of on-orbit interactions, potentially causing international incidents.

For example, in December 2021 China submitted a note verbale to the United Nations in which officials complained that a SpaceX Starlink satellite had come dangerously close to China's human-tended space station. The United States responded that based on data from the U.S. SSA system, the U.S. did not believe that a close approach had occurred. This may have been a politically-motivated incident, but it is also possible that this issue arose due to differences in data and analysis that led to different understandings of the relative locations of the space assets involved. There may also have been a difference in the thresholds for determining "high risk." Without better engagement between nations, it is difficult to understand the source of these types of challenges. With the additional transparency made possibly through a civil SSA agency, the United States could further elaborate on its understanding of the space environment. Continued transparency, as well as engagement with other nations will also allow the U.S. to set a standard

[11] Borowitz, Mariel. "Examining the Growth of the Global Space Situational Awareness Sector: A Network Analysis Approach." *Space Policy* 59 (2022): 101444.
[12] Borowitz, Mariel. "Legal Considerations and Future Options for Space Situational Awareness." *Georgia Journal of Internationall & Comparative. Law* 48 (2019): 695.

of behavior and can help to avoid potential misunderstandings in the future – with both partners and potential competitors.

**5. How will this transition affect future developments in space, including space traffic coordination and management?**

High-quality, widely-available space situational awareness information is critical, but there is more that needs to be done to ensure the safety and sustainability of space activity in the future. Space situational awareness allows us to understand what's happening in space and generate warnings when collisions may occur, but operators do not have any guidelines or requirements that govern their behavior in these cases.

This is the equivalent to telling a driver they are approaching a busy intersection, but leaving them completely in the dark as to whether they are expected to slow or stop or whether other cars are likely to do so. It is not clear whether the car on the left has the right of way or the car on the right. Every interaction must be negotiated on a case-by-case basis, and – to continue the analogy – we can't guarantee the other driver will even respond or engage in this negotiation. This is not efficient and it is not safe.

Eventually we will need to develop operational norms of behavior for outer space, just as we have for cars, ships, and aircraft. When we begin to address the issue of Space Traffic Coordination and Management, high-quality SSA information, transparency, trust, and international and commercial engagement will be more important than ever. The United States needs to take the steps described above to lay the foundation for success in this important future task. With an organized, efficient, and transparent civil SSA system that brings together military, civil, commercial, and academic communities, the United States will be able to take an international leadership role on this important issue.

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**Biography**

Mariel Borowitz is an Associate Professor in the Sam Nunn School of International Affairs at Georgia Tech. Her research deals with international space policy issues, including international cooperation in Earth observing satellites and satellite data sharing policies. She also focuses on strategy and developments in space security and space situational awareness. Dr. Borowitz earned a PhD in Public Policy at the University of Maryland and a Masters degree in International Science and Technology Policy from the George Washington University. She has a Bachelor of Science degree in Aerospace Engineering from the Massachusetts Institute of Technology. Dr. Borowitz completed a detail as a policy analyst for the Science Mission Directorate at NASA Headquarters in Washington, DC from 2016 to 2018. Her book, "Open Space: The Global Effort for Open Access to Environmental Satellite Data," was published by MIT Press in 2017.