Hearing of the Subcommittee on Space and Aeronautics

U.S. House of Representatives

"Space Situational Awareness: Examining Key Issues and the Changing Landscape"

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1. Introduction

Madam Chair, distinguished members of this subcommittee, thank you for the opportunity to provide written testimony on this important issue. Secure World Foundation is dedicated to ensuring the long-term sustainability of space activities so that all of humanity can continue to use space for benefits on Earth. Space situational awareness (SSA) is the foundation of space sustainability and working to improve SSA capabilities for all actors is a major part of our work.

On January 29, 2020, two dead satellites nearly collided about 900 kilometers (560 miles) over the city of Pittsburgh.[1] The Gravity Gradient Stabilization Experiment (GGSE-4) was an Air Force technology experiment launched in 1967 and the Infrared Astronomical Satellite (IRAS) was a space-based telescope launched by NASA in 1983. Both had been dead for decades and there was an unusually high chance they would collide. The last such on-orbit collision between two satellites occurred on February 10, 2009, when an inactive Russian military communications satellite (Cosmos 2251) collided with an active commercial communications satellite operated by U.S.-based Iridium Satellite, LLC.[2] The Iridium-Cosmos collision generated nearly 2,000 pieces of orbital debris bigger than a softball, most of which will remain on orbit for decades to come. Thankfully, in this latest incident, both GGSE and IRAS passed each other in orbit without incident at an estimated distance of about 18 meters (60 feet).

Comparing the Iridium-Cosmos collision with the GGSE-IRAS near hit highlights what has and has not changed over the intervening eleven years. In 2009, there were less than 1,000 active satellites in orbit and around 15,000 pieces of cataloged orbital debris. The only public source of

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[1] LeoLabs has published an extensive write-up and analysis of this event here: https://medium.com/@leolabs_space/the-iras-ggse-4-close-approach-a99de19c1ed9

[2] Prior to the Iridium-Cosmos collision, there had been previous collisions in orbit between two pieces of space debris or between a satellite and a piece of space debris, but not between two satellites. Since then, there have been other suspected incidents of active satellites being struck by orbital debris but none resulting in catastrophic destruction.

data on close approaches and collisions between space objects was the U.S. Air Force's First Space Control Squadron, and at that time they were only monitoring for close approaches involving a relatively short list of about 150 important U.S. national security, civil, and human spaceflight objects. As a result of the Iridium-Cosmos collision, U.S. policy changed in 2010 to broaden the SSA mission of the U.S. Air Force, which today provides close approach warnings to all satellite operators globally.[3]

Today there are more than 2,200 active satellites in orbit along with more than 20,000 pieces of cataloged orbital debris. The first public notice of the GGSE and IRAS close approach was a tweet three days before the event from a commercial company, LeoLabs, which operates its own network of ground-based tracking radars that feed into its own catalog of space objects. LeoLabs is one of several commercial companies that have entered the SSA sector in the last decade and who collectively now provide a broad suite of capabilities for tracking space objects in all Earth orbits and an increasingly sophisticated set of analytical products based on that tracking.

In both cases, the best available tracking data and conjunction algorithms were only able to provide a probabilistic answer to whether the two objects would collide. In the case of Iridium-Cosmos, analyses using the lower-quality data made public by the U.S. Air Force at the time suggested they would come within 117 meters to 1.812 kilometers (384 feet to 1.1 miles) over the seven days prior to the collision.[4] The U.S. Air Force has not publicly stated what its internal analysis showed prior to the collision, nor did the public data it made available allow for calculation of a collision probability.[5] For the GGSE-IRAS close approach, LeoLabs provided a visualization four days prior to the event and an updated estimate that ranged from a miss distance of 12 to 100 meters (40 to 330 feet), and a probability of collision that ranged between 1 in 100 to 1 in 1000. After the predicted close approach, both LeoLabs and the U.S. Space Force's 18th Space Control Squadron provided independent public confirmation that the two satellites had indeed missed each other.

The Iridium-Cosmos collision served as a wake-up call for the entire space community to the threat that orbital debris poses to active satellites as well as the importance of SSA for detecting and avoiding future collisions. The Iridium-Cosmos collision also heightened the salience of SSA as a mission area and drove increased focus from policymakers around the world and increased investment in improving SSA capabilities. Some of that focus and investment has resulted in meaningful improvements, yet serious gaps and shortfalls still remain.

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[3] An overview of the SSA Sharing Program that established these changes can be found here: https://swfound.org/media/3584/ssa_sharing_program_issue_brief_nov2011.pdf

[4] An overview and technical analysis of the Iridium-Cosmos collision can be found here: http://celestrak.com/events/collision/

[5] Air Force Space Command conducted an unclassified review of the incident, but the report has never been made public.

The key issue still facing the U.S. government is the transition of responsibilities for civil and safety-related SSA activities from the Department of Defense (DOD) to a civil agency as part of establishing a national space traffic management (STM) regime. Beginning in the summer of 2010, the Obama Administration had an interagency group that worked on STM policy on-and-off for the next six years, which laid the foundation for Space Policy Directive 3 (SPD-3) that was issued by the Trump Administration in June 2018.[6] However, Congress has not yet enacted the changes in authorities and budget that would enable the full implementation of SPD-3 or an alternative solution. The lack of action is due to disagreements between the House and Senate on the importance of assigning new authorities as well as the lack of coordination between the multiple committees with jurisdiction. As a result, creating a civil SSA entity and establishing a STM regime lies in limbo, preventing much-needed progress on managing orbital debris, preventing satellite collisions, and ensuring the long-term sustainability of space.

There are a few other public policy issues that need to be tackled as well. These are competition and overlap between government SSA programs and emerging commercial capabilities, an economic goods analysis of SSA and ensuring the right SSA products and services are available to all user communities, and reducing the restrictions on non-Earth imaging that hinder innovation and development of commercial on-orbit SSA capabilities.

Finally, there is the continued failure of the DOD to improve the computer systems that underpin its own SSA capabilities. In 2004, as a young U.S. Air Force Captain in training prior to an assignment with the 1st Space Control Squadron, I was told the two computer systems we were trained to use would be replaced in 2005. Today, those same two computer systems are still in use and form the backbone of the DOD's SSA capability. There have been multiple failed acquisition programs over the last two decades to try and replace those systems at significant taxpayer expense.[7] While this subcommittee is not responsible for oversight of those programs, the lack of shift to a civil agency providing SSA means the safety of all civil and commercial satellites is beholden to the shortcomings in military systems created by these programmatic failures.

The remainder of my written testimony focuses on the role SSA plays in supporting space sustainability, including enabling orbital debris mitigation, active debris removal, and space traffic management. It concludes with a discussion of current national policy landscape and the public policy and administration issues that need to be addressed by Congress. My testimony refers to and leverages a broader written testimony on a very similar topic that I provided to this

[6] The text of Space Policy Directive 3 can be found here: https://www.whitehouse.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/

[7] For a summary of these failures up to 2012, see http://swfound.org/media/90775/going_blind_final.pdf For a summary of the failures since 2012, see https://www.gao.gov/assets/710/702424.pdf

subcommittee in a previous hearing[8] held in May 2014, while also emphasizing what has, and has not, changed in the intervening six years.

2. Background on the Current Orbital Debris Environment

More than 70 entities (countries, commercial companies, and international organizations) currently operate more than 2,200 satellites in orbit around Earth.[9] These satellites provide a wide range of social and private benefits, including enhanced national and international security, more efficient use and management of natural resources, improved disaster warning and response, and near-instantaneous global communications and navigation.

Orbital debris - dead satellites, spent rocket stages, and other fragments associated with humanity's six decades of activity in space - represents a growing threat to active satellites. The DOD tracks close to 23,000 pieces of human-generated debris in Earth orbit larger than 10 centimeters (4 inches) in size, each of which could destroy an active satellite in a collision. Statistical modeling indicates there are an estimated 900,000 pieces of orbital debris between 1 and 10 centimeters (0.4 to 4 inches) in size that are largely untracked, each of which could severely damage an active satellite in a collision.[10]

As orbital debris is generated by humanity's activities in space, it is concentrated in the most heavily used regions of Earth orbit where many active satellites also reside. These regions include the low Earth orbit (LEO) region below 2,000 kilometers (1,200 miles) in altitude and the geostationary Earth orbit (GEO) region, approximately 36,000 kilometers (22,000 miles) above the equator. Of the two regions, LEO currently presents the most pressing challenge for long-term sustainability and increasing collision threats to satellites from orbital debris.[11]

Former NASA scientist Donald Kessler was one of the first to predict what has since become known as the Kessler Syndrome.[12] As the amount of space debris in orbit grows, he predicted there would be a critical point where the density of orbital debris would lead to random collisions between orbital debris. These random collisions would in turn generate more debris at a rate

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[8] https://swfound.org/media/169974/weeden%20testimony_may2014.pdf

[9] The most accurate public estimate of the active satellites current in Earth orbit is the database maintained by the Union of Concerned Scientists available here:
https://www.ucsusa.org/resources/satellite-database

[10] For an overview of current estimates of orbital debris, see the European Space Agency website:
https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers

[11] The debris threat in the GEO region is not yet as significant as in LEO, but that may change in the near future. For an excellent overview of the debris threat in GEO, see Mcknight, DS and Di Pentino, FR, "New insights on the orbital debris collision hazard at GEO", *Acta Astronautica*, http://dx.doi.org/10.1016/j.actaastro.2012.12.006

[12] Don's own summary of the history of the Kessler Syndrome can be found here:
http://webpages.charter.net/dkessler/files/KesSym.html

faster than orbital debris is removed from orbit by the Earth's atmosphere. Unlike the dramatic scenario presented in the movie *Gravity*, this process would take place much more slowly over decades or centuries. Space was also not a pristine environment before humans began to fill it with satellites. There has always been a natural debris environment in space due to micrometeoroids. Kessler's prediction was that these cascading debris-on-debris collisions would result in a human-generated debris population that would pose more of a threat to satellites than the natural debris.

There is now a general consensus among scientists that this critical point has come to pass and there is enough human-generated orbital debris concentrated in the critical region in LEO between 700 and 900 kilometers (430 to 560 miles) to create more debris even if no new satellites were launched. Computer simulations conducted by six different space agencies predict that this critical region will see additional catastrophic collisions similar to Iridium-Cosmos every five to nine years.[13]

These debris-on-debris collisions will not lead to an infinite growth in the debris population. Rather, they will lead to a future equilibrium point that has a larger population of debris than today. This increased amount of debris will increase the risks and thus the associated costs of operating satellites in critical regions such as LEO. These increased costs could come about through the need for more spare satellites to replace those lost in collisions, heavier and more overly engineered satellites that cost more to build and launch, and increased operating costs to try to detect and avoid potential collisions. These rising costs will likely hinder commercial development of space and will place additional pressure on government budgets, potentially resulting in the loss of some of the benefits we currently derive from space.

Recently, there has been the additional challenge of renewed interest in large satellite constellations.[14] Multiple commercial companies and governments have announced plans to develop and launch constellations ranging from 100 to more than 40,000 satellites each into low Earth orbit between 550 and 1300 kilometers (341 to 808 miles) in altitude. The purpose of these constellations is to either collect imagery and other remote sensing data about the Earth or to provide broadband internet and other communications services to the world, both of which would deliver valuable socioeconomic benefits. However, the sheer size of the planned constellations has driven concerns that they will worsen the orbital debris situation. Modeling done by the European Space Agency of a single 1,000 satellite constellation indicates they will need to comply with strict post-mission disposal and reliability requirements in order to

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[13] These simulations can be found in the study "Stability of the Future LEO Environment", IADC-12-08 Rev 1, January 2013: http://www.iadc-online.org/Documents/IADC-2012-08,%20Rev%201,%20Stability%20of%20Future%20LEO%20Environment.pdf

[14] For a comparison of the current large constellation proposals with those made during the 1990s, see: https://www.thespacereview.com/article/3747/1

minimize their long-term impact on the space environment.[15] A more in-depth study by NASA that included multiple constellations totaling 8,000 satellites found 99% post-mission disposal and fewer than 1 in 1000 accidental explosions were necessary to avoid a dramatic increase in the orbital debris population.[16]

3. A Holistic Plan for Space Sustainability

Dealing with the orbital debris challenge outlined above requires a holistic approach to space sustainability as shown in Figure 1. Three main lines of effort – debris mitigation, active debris removal (remediation), and space traffic management – are all supported and rely on a foundation of SSA and national policy and regulations. Mitigation, remediation, and traffic management are all complementary initiatives that tackle different aspects of the orbital debris challenge – past, present, and future. Only by undertaking all three can we deal with the problem in a comprehensive manner. Without appropriate and accurate information on the space environment and activities in space, it is impossible to effectively manage the space environment or provide proper oversight in accordance with international obligations.

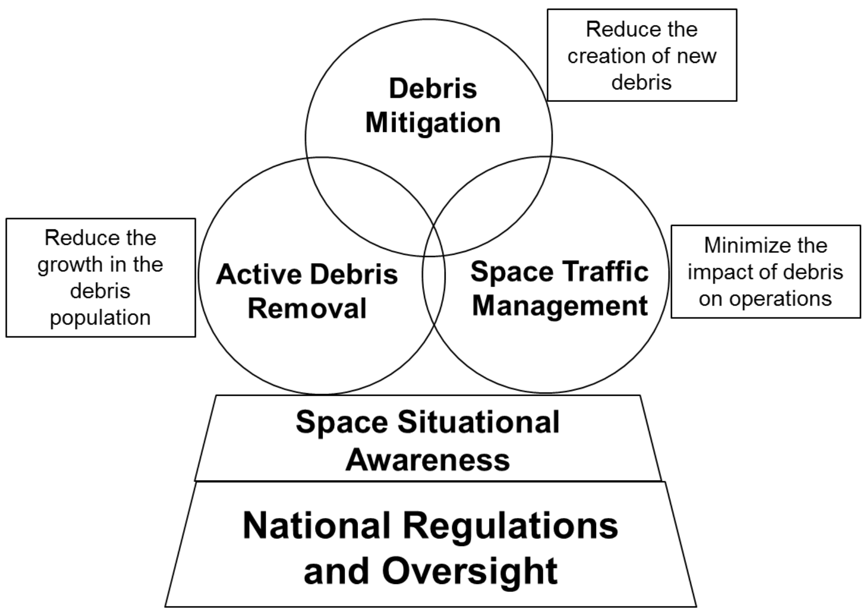

Figure 1. A framework for space sustainability

From a national perspective, it is important to have in place the proper regulations and oversight mechanisms to support all of the activities outlined above across both governmental and non-

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[15] A copy of the ESA study can be found here: https://conference.sdo.esoc.esa.int/proceedings/sdc7/paper/507

[16] A copy of the NASA study can be found here: http://www.parabolicarc.com/2018/09/25/nasa-odpos-large-constellation-study/

governmental space activities. These include pragmatic and well-defined licensing requirements for the private sector as well as the ability to continually monitor and enforce those requirements, and clearly defined roles, responsibilities, and interagency protocols in place between the various government entities. At the same time, it is also important to keep in mind the international context, and the interactions and relationships between the activities and capabilities of the United States and the many other countries currently active, and soon to be active, in space.

3.1 Orbital Debris Mitigation

Orbital debris mitigation is defined as limiting the creation of new debris through human activities in space. This process includes designing satellites and space systems so as to minimize the amount of debris they release during normal operations, developing methods to reduce the risk of fragmentation or explosion at the end of life by venting leftover fuel or discharging batteries, and properly disposing of spacecraft and spent rocket stages after they are no longer useful.

Historically, the United States has been a world leader in both developing orbital debris mitigation guidelines and in implementing them through national regulation. NASA was a founding member of the Inter-Agency Space Debris Coordination Committee (IADC) where it worked with other major space agencies on developing technical debris mitigation guidelines and continues to conduct scientific research on space debris.[17] The key piece of the existing IADC orbital debris mitigation guidelines is the so-called "25-year rule," which says satellites and associated orbital debris should not remain in protected regions of orbit for longer than 25 years beyond their end of mission.

The U.S. government has also put in place some of the most comprehensive policy and regulatory instruments to implement these technical guidelines in national space activities.[18] At the top level, the 2010 National Space Policy of the United States identified "Preserving the Space Environment and the Responsible Use of Space" as one of its seven intersector guidelines. It directs federal agencies to implement the U.S. Government Orbital Debris Mitigation Standard Practices (ODMSP) in their space activities. Space Policy Directive 3 issued by the Trump Administration on June 18, 2018, reinforced the focus on orbital debris mitigation and directed a review of the ODMSP. Led by NASA, that review concluded in late 2019 with the publication of an updated set of ODMSP.[19] However, the update was minimal and fell significantly short of

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[17] The IADC Space Debris Mitigation Guidelines can be found here: http://www.iadc-online.org/Documents/IADC-2002-01,%20IADC%20Space%20Debris%20Guidelines,%20Revision%201.pdf

[18] An overview of these authorities and the relevant regulations can be found in a conference room paper presented by the U.S. delegation to the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space on March 24, 2014: http://www.oosa.unvienna.org/pdf/limited/c2/AC105_C2_2014_CRP15Add01E.pdf

[19] The updated ODMSP can be found here: https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf

what many outside observers felt was necessary to stay ahead of real-world space sustainability challenges, and continue America's leadership role on debris mitigation.

3.2 Remediation and Active Debris Removal

The existing population of orbital debris will continue to grow over time, even without any new space launches and even with full compliance with the existing mitigation guidelines. In 2011, a study conducted by six space agencies using six different models found an average increase of 30 percent in the LEO orbital debris population over the next 200 years, even with 90 percent adherence to the 25-year rule.[20] Current adherence is around 60% and shows a slight upward trend over time.[21]

Thus, NASA and other space agencies have concluded that actively removing existing orbital debris (ADR), a process also known as remediation, will be necessary. These removal or remediation efforts can take one of two different directions, depending on the goal. If the goal is to reduce the growth in the debris population and reduce the threat over the long term, then the objective should be to remove five to ten of the largest debris objects per year. This would eliminate these large objects as potential sources of new debris should they collide with another object. But if the goal is to reduce the threat to operational satellites in the short term and medium term, then the objective should be to remove the small debris objects in the size range between 1 and 10 centimeters (0.4 and 4 inches). These objects are too small to be tracked by current space surveillance systems, and while an impact with them is unlikely to result in a catastrophic collision, it could severely damage or be lethal to an active spacecraft.

Technical experts from around the world have been working intensely on both of these problems over the last decade, and there are some promising technical solutions for removing either large objects or small objects. There are a handful of companies, such as Astroscale, D-Orbit, and ClearSpace, that are working on developing ADR technology for different categories of missions. However, there is unlikely to be a "silver bullet" solution that can deal with both objectives. Moreover, none of these techniques have yet been fully demonstrated in orbit[22] and all of them pose a wide range of legal, policy, and other non-technical challenges.[23] Solving

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[20] These simulations can be found in the study "Stability of the Future LEO Environment," IADC-12-08 Rev 1, January 2013: http://www.iadc-online.org/Documents/IADC-2012-08,%20Rev%201,%20Stability%20of%20Future%20LEO%20Environment.pdf

[21] The most complete public analysis of this compliance can be found in the annual ESA Space Environment Report: https://www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf

[22] There have been limited experiments of specific technologies or procedures, such as those conducted by the European RemoveDebris mission (https://directory.eoportal.org/web/eoportal/satellite-missions/r/removedebris), but as of yet no demonstrations of removing an existing debris object from orbit.

[23] An overview of these challenges can be found in Weeden, B, "Overview of the legal and policy challenges of orbital debris removal," *Space Policy*, http://dx.doi.org/10.1016/j.spacepol.2010.12.019

those challenges will require close coordination and cooperation among the engineers and scientists working on the technology, as well as the lawyers and policymakers developing policy and regulatory oversight.

There are also complementary activities to ADR, primarily just-in-time collision avoidance (JCA). Instead of removing orbital debris, JCA would change the orbit of one of the pieces of orbital debris involved in a very close approach, thus preventing a potential collision.[24] JCA could be done using ground-based lasers to alter the trajectory of a piece of debris, or by creating aerosol clouds in orbit that will slow down objects passing through.[25] However, these technologies are in the early stages of development, and JCA techniques also present a number of legal and policy challenges. That said, JCA could be an important tool to prevent catastrophic collisions and provide more time to develop and carry out direct removal.

The United States has not yet developed or demonstrated the capability for ADR or remediation writ large, or even invested significant funding in R&D, despite clear policy direction to do so for nearly a decade. The 2010 National Space Policy tasked both the DOD and NASA to "pursue research and development of technologies and techniques…to mitigate and remove on-orbit debris." In the intervening ten years since that policy was issued, there have only been a small number of contracts awarded by NASA to do limited risk-reduction studies on debris removal technologies.[26]

The unwillingness of NASA or the DOD to develop ADR technologies is likely due to public policy and administration concerns. Neither has ADR as a core mission area, and neither is funded to develop ADR; and as a result, both are unwilling to take on an unfunded mandate. In June 2014, NASA formally adopted a policy to limit its ADR efforts to basic research and development of the technology up to, but not including, on-orbit technology demonstrations.[27]

Furthermore, the DOD has historically been very sensitive to international perceptions that it is weaponizing space, not necessarily because it does not want to do so, but because of the political impact such perceptions may have on domestic support in Congress and international support from its allies. Thus, the U.S. national security space community has strong concerns that any military-backed initiative for ADR may stimulate comparable programs by others in response or

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[24] An overview of the JCA concept and a comparison to ADR can be found in McKnight, DS, Di Pentino, F, Kaczmarek, A, and Dingman, P, "System engineering analysis of derelict collision prevention options", *Acta Astronautica*, http://dx.doi.org/10.1016/j.actaastro.2013.04.016

[25] An overview of one concept for using ground-based lasers to do JCA can be found in Mason, J, Stupl, J, Marshall, W, and Levit, C, "Orbital Debris-Debris Collision Avoidance", arXiv, http://arxiv.org/abs/1103.1690

[26] The history of U.S. national policy on orbital debris and the lack of progress on ADR technology development can be found here: https://www.thespacereview.com/article/3361/1

[27] Reporting on the policy can be found here: http://spacenews.com/nasas-interest-in-removal-of-orbital-debris-limited-to-tech-demos/

create geopolitical complications. These concerns have shifted recently with the DOD's public declaration that space is a warfighting domain and increased focus on developing new offensive counterspace capabilities, but the same shift has also reduced the DOD's concern about orbital debris.

At some point it will be necessary to conduct one or more on-orbit technology demonstration missions for ADR to both prove the concepts and do further risk reduction. Such missions would also be very useful for working out some of the specific legal, policy, and other non-technical challenges of conducting debris removal, particularly if they involved commercial entities and international partners. In lieu of any U.S. action on this issue, the European Space Agency has recently commissioned the world's first ADR mission to fund a Swiss company to remove a small upper stage from orbit.[28]

3.3 Space Traffic Management

The third major category of efforts to deal with orbital debris is space traffic management (STM). STM as defined by SPD-3 is the planning, coordination, and on-orbit synchronization of activities to enhance the safety, stability, and sustainability of operations in the space environment.

Under that definition, the largest element of STM is detecting and mitigating collisions between active satellites and other space objects. While there is some similarity between how this is done in space and air traffic management, the two concepts are not completely analogous. The most important difference between the two is the speed at which objects in space move. The speed of an object in orbit is dictated by its orbital altitude. The lower in altitude an object's orbit is, the faster it must move to avoid being pulled into the atmosphere by the Earth's gravity. At 800 kilometers (500 miles) altitude, an object in orbit travels at approximately 7.5 kilometers per second (17,000 miles per hour). The most likely scenario for a collision is when two objects in similar orbits at the same altitude cross paths near one of the Earth's poles, and in those cases the combined relative speed can be upwards of 10 to 14 kilometers per second (22,300 to 31,300 miles per hour).

As a result, most objects on a collision course in space move too fast for the human eye to see, and collisions will likely happen much faster than any human could possibly react to. Trying to develop a regime of active, real-time space traffic control of all space objects by humans is impractical. Such active management is likely only useful for objects that are conducting a planned orbital rendezvous or in proximity to a human-occupied object. Moreover, even an automated reaction to avoid a collision at the last minute is likely not feasible. The extremely

[28] More information on the EA ClearSpace-1 mission can be found here: https://www.esa.int/Safety_Security/Clean_Space/ESA_commissions_world_s_first_space_debris_removal

short amount of time to react would require a massive amount of thrust to alter the spacecraft's orbit, compared to a maneuver made well before.

Instead, as shown by the earlier examples of both the Iridium-Cosmos collision and the GGSE-IRAS close approach, STM is almost entirely a predictive process done by computers and sophisticated software. This process, known as conjunction assessment, uses estimates of the orbital trajectories of tracked space objects, the error in those estimates, and models of the Earth's atmosphere and other perturbations to predict where space objects will likely be a few days into the future. This process does not result in a definitive "yes" or "no" answer as to whether or not two objects in orbit will collide. The numerous uncertainties present in each input to the calculation, mandate that the best it can currently do is provide a probability of collision between two objects.

Based on these conjunction assessments, a warning is provided to the satellite operator or operators involved, along with the probability of collision. It is currently up to each operator to establish their own risk tolerance and use that as a basis for determining whether or not to maneuver their satellite to change its trajectory and avoid the conjunction. This is not always a straightforward decision to make, as maneuvering consumes fuel that could reduce the operational lifespan of the satellite and may interrupt the services it provides or the mission it is conducting. Moreover, maneuvering comes with its own risks as it may in some circumstances make the situation worse or create an even more dangerous close approach in the future.

Risk tolerance will vary between satellite operators and with the mission the satellite is performing. For example, NASA has determined that if the probability of collision between a piece of orbital debris and the International Space Station is greater than 1 in 100,000, a maneuver will be conducted if it will not result in significant impact to mission objectives.[29] If the probability is greater than 1 in 10,000, a maneuver will be conducted unless it will result in additional risk to the crew. For most robotic satellites, the risk tolerance for maneuvers is between 1 in 1,000 and 1 in 10,000.

The other major difference between air and space traffic is that the vast majority of space traffic has no ability to maneuver to avoid a collision. Less than five percent of the tracked space objects bigger than 10 cm are active payloads, and not all active payloads have maneuvering capability. Although the GGSE-IRAS close approach did not result in a collision, that was not a unique occurrence and there are similar events occurring all the time. LeoLabs estimated four other similarly close approaches happened around the same time as the January 29th GGSE-IRAS event. The most worrisome debris-on-debris close approaches are those involving clusters of very large spent upper stages, most of which are Russian and periodically come within 100

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[29] An overview of NASA's collision avoidance procedures can be found here: http://www.nasa.gov/mission_pages/station/news/orbital_debris.html

meters of colliding.[30] Each of those clusters has the same mass as the entire planned OneWeb constellation and a collision between two of them could double the size of the current cataloged orbital debris population.[31]

In addition to on-orbit close approaches, another important element of STM is the interface between orbital traffic and air traffic. In 2016, more than 250 tracked space objects, amounting to more than 50 metric tons, re-entered the Earth's atmosphere according to data provided by the DOD and NASA.[32] The rest were uncontrolled re-entries of more than 100 metric tons of dead payloads, spent rocket stages, and smaller bits of debris. Tracking data on these objects are combined with models of the Earth's atmosphere to predict where they might re-enter. However, this process has significant uncertainties and currently it is not possible to predict with any certainty exactly when and where a space object will re-enter the atmosphere more than a couple of hours in advance, except under very specific circumstances.

The odds of a re-entering space object hitting an aircraft in flight is extremely remote, largely because air traffic is concentrated over a relatively small fraction of Earth's landmasses. However, there are certain circumstances, such as the tragic breakup of Space Shuttle Columbia on its re-entry approach over the United States, where a large amount of orbital debris may pose a hazard to air traffic. Additionally, the emergence of reusable rocket stages that return to their launch pad and potential growth of sub-orbital tourism is already driving close integration between air and space traffic through efforts such as the FAA's Space Data Integrator.[33]

3.4 Space Situational Awareness (SSA)

All of the efforts to deal with the threat of orbital debris – debris mitigation, debris removal, and STM - rely on SSA. SSA, broadly defined as characterizing the space environment and its impact on activities in space, is a fundamental requirement for successfully tackling the many challenges related to the long-term sustainability of space activities. SSA began as the military space surveillance mission, and in recent years has expanded to include more types of information as well as additional services.

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[30] This assessment comes from research done by Dr. Darren McKnight on the collision risk posed by clusters of large rocket bodies. A summary of his recent work can be found here: https://spacenews.com/clusters-not-constellations-pose-biggest-orbital-debris-risk/

[31] Ibid.

[32] This information comes from a presentation by Jer-Chyi Liou from NASA to the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space on February 1, 2017, available here: http://unoosa.org/documents/pdf/copuos/stsc/2017/tech-15E.pdf

[33] More information about the Space Data Integrator can be found here: https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=23476

SSA includes multiple categories of data. The first is metric data, which are observations of space objects that are combined to determine orbital trajectories. The second category is characterization data, which are measures of size, shape, broadcast frequencies, brightness, and other data that provide information about a space object's composition and capabilities. The third category is space weather, which includes data on the interaction between the Sun and Earth's magnetosphere that impacts orbital decay and could cause anomalies in or damage to active satellites. The fourth category is the detection, tracking, and characterization of asteroids and other Near-Earth Objects (NEOs) that could pose a collision risk to the Earth.

The DOD currently has the most comprehensive SSA capability in the world.[34] This includes operating the largest tracking network of ground and space-based sensors and maintaining one of the most complete catalogs of objects in Earth orbit. Its Space Surveillance Network (SSN) consists of more than 30 radars and optical telescopes located around the world and in orbit. Tracking data from the SSN are collated and analyzed by the U.S. Space Force's 18th Space Control Squadron (18 SPCS) at Vandenberg Air Force Base in California. The 18 SPCS maintains a catalog of space objects and uses that catalog to provide a variety of services and functions. It also makes a lower-accuracy portion of its catalog publicly available on the Internet.

The main drawback to the current DOD SSA capabilities is the location and distribution of the tracking sites. Many of their tracking radar locations are optimized for their original missile warning functions and are thus located on the northern borders of the United States. This means that the system's coverage is focused mainly in the Northern Hemisphere. Thus, there are large gaps in the tracking coverage for LEO space objects and sometimes significant time between tracks. There are efforts underway to alleviate some of these gaps, such as the recent installation of a radar and an optical telescope in Australia[35] and the creation of the first S-Band Space Fence on Kwajalein Atoll,[36] but significant gaps in coverage, capacity, and timeliness still remain.

Over the last decade, many other countries have also increased their own interest in and capabilities for SSA. Russia still maintains the largest and most complete network of government sensors outside the U.S., but China has focused significant efforts on developing its own network. The European Union and European Space Agency have both had Space Surveillance and Tracking (SST) efforts since 2009 aimed at integrating data from multiple European sensors

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[34] An overview of global SSA capabilities can be found in Weeden, B, Cefola, P, and Sankaran, J, "Global Space Situational Sensors," paper presented at the 2010 Advanced Maui Optical and Space Surveillance Conference. Available from: http://swfound.org/media/15274/global%20ssa%20sensors-amos-2010.pdf

[35] For more information on the move of the C-Band radar see https://www.peterson.af.mil/News/Article/1114478/c-band-radar-reaches-full-operational-capability-in-australia/ For more information on the move of the Space Surveillance Telescope, see https://breakingdefense.com/2019/07/air-force-eyes-new-deep-space-sensors-in-australia-spain/

[36] The current status and operational testing report for the S-Band Space Fence can be found here: https://www.c4isrnet.com /battlefield-tech/space/2019/12/11/a-new-radar-to-track-space-objects-is-almost-ready/

and developing new ones. Individual European countries such as France, Germany, Italy, and the United Kingdom have also funded national efforts to develop SSA capabilities. Outside of Europe, Australia, Japan, India, South Korea, and the United Arab Emirates are just a few of many countries to increase their national focus on SSA over the last decade.

Another remaining challenge is the need to combine the tracking of orbital debris and other non-cooperative space objects with owner-operator data on active satellites. A satellite operator typically has much more precise data on the location and trajectory of their own satellite than can be determined by remote analysis. Moreover, satellite operators also are aware of upcoming maneuvers they plan to conduct. Without knowledge of these maneuvers, future predictions of their satellite's trajectory and any potential close approaches it has can be disastrously wrong.

From a policy perspective, current U.S. national space policy emphasizes the important role SSA plays in preserving the space environment. It directs the federal government to develop, maintain, and use space situational awareness (SSA) information from commercial, civil, and national security sources to detect, identify, and attribute actions in space that are contrary to responsible use and the long-term sustainability of the space environment.[37] It states that the Secretary of Defense, in consultation with the Director of National Intelligence, the Administrator of NASA, and other departments and agencies, may collaborate with industry and foreign nations to: maintain and improve space object databases; pursue common international data standards and data integrity measures; and provide services and disseminate orbital tracking information to commercial and international entities, including predictions of space object conjunction. Current policy also identifies SSA as a key area for potential international cooperation and data sharing.

3.5 National Regulation of Private Sector Space Activities

A key part of the current changes in the space domain is the growth in number and diversity of commercial space activities. Billions of dollars in public and private capital are flowing into the commercial space sector, resulting in expanding capabilities to existing commercial space sectors, such as communications and remote sensing, as well as development of completely new capabilities such as satellite servicing, private space stations, and resource extraction and utilization. While the United States already has a national framework for providing oversight to some categories of commercial space activities, it does have significant gaps and shortcomings relative to the pace of change in the commercial sector.

There are currently three U.S. federal agencies with existing regulatory authority over non-governmental space activities. The National Oceanic and Atmospheric Administration (NOAA) under the Department of Commerce (DOC) has the authority to license non-governmental space-based remote sensing of Earth. The Federal Aviation Association (FAA) under the Department of Transportation (DOT) has licensing authority over commercial launch, re-entry or reusable

[37] The 2010 National Space Policy can be found here: https://history.nasa.gov/national_space_policy_6-28-10.pdf

vehicles, commercial launch or re-entry facilities, and also commercial human spaceflight. The Federal Communications Commission (FCC) also has the authority to provide licenses to radio frequency spectrum for non-governmental satellite activities. All three of these entities include orbital debris mitigation as part of their licensing process, although there are some differences in how they do so.

There are several types of commercial space activities planned for the near future that do not clearly fall under any of these existing licensing authorities. These gaps create uncertainty that gives rise to real-world challenges for start-up companies trying to secure investors and insurers, a phenomenon many new space companies are struggling with. Providing a clear legal pathway for all commercial space companies, including those with new and innovative ideas, to secure a license would send a strong positive signal to markets and encourage more entrepreneurship. Doing so would also help bolster the leadership role the United States has traditionally played on space governance. Historically, other countries have modeled their national policy and regulation on the example provided by the United States. And as more countries acquire the capability to engage in commercial space activities, it will be important for U.S. companies to be working inside a predictable international legal framework that can encourage and protect investments.

Since 2010, both the Executive and Legislative branches have been engaged in a debate about reforming or updating these existing authorities to close these gaps. In response to a report directed by the 2015 Commercial Space Launch Competitiveness Act, the Obama Administration proposed a "mission authorization" framework that leveraged the FAA's existing Payload Review process.[38] Although legislation to enact Mission Authorization in some form has since been introduced in both the House and Senate, to date the two chambers have failed to come to agreement and enact it into law.

Putting in place a more robust national framework for oversight of private sector activities depends heavily on SSA. SSA data provides foundational data on the existing state of the space environment and how it is being impacted by expanding commercial space activities. Thus, good SSA data is a critical input to shape the norms and regulations that will apply to current and future space activities. SSA is also critical to monitoring space activities, enforcing regulatory requirements, and identifying and highlighting irresponsible actions and actors in space.

4. Recommendations for Reform on SSA and STM

Since the Iridium-Cosmos collision in 2009, the United States has reshaped its national policy on SSA. While these efforts have resulted in meaningful improvements, there is still much that needs to be done, particularly on Congressional implementation of these policy efforts in both legal authorities and budget.

[38] The report from the Office of Science and Technology Policy can be found here: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/csla_report_4-4-16_final.pdf

As discussed earlier, before the 2009 Iridium-Cosmos collision, the DOD was one of the few entities detecting close approaches between select space objects. After the collision, a policy decision was made in 2010 that directed the DOD to provide close approach warnings to all satellite operators and expand the range of data and analysis products they offer to commercial and foreign entities. This change was enshrined in the 2010 National Defense Authorization Act.

In addition to providing expanded close approach screenings, the DOD was also authorized to sign SSA data sharing agreements with commercial and foreign entities. To date, the DOD has signed data sharing agreements with Australia, Japan, Italy, Canada, France, South Korea, the United Kingdom, Germany, Israel, Spain, the United Arab Emirates, Belgium, Norway, Denmark, Brazil, the Netherlands, Thailand, New Zealand, Poland and Romania, the European Space Agency, the European Organization for the Exploitation of Meteorological Satellites, and 78 commercial satellite owners or operators.[39] While a few of these agreements involve current one-way or two-way data exchange, most establish the framework for future bilateral data exchanges.

However, reliance on the DOD for all of SSA still has its shortcomings. The DOD has struggled to provide greater transparency into its processes for creating and delivering SSA products and services as well as to upgrade its computer systems to bring in non-traditional SSA data and data from satellite owner-operators. DOD leadership also expressed concerns about the safety mission drawing resources and time away from the national security mission, which has seen renewed focus with the return of Great Power Competition from Russia and China.

Simultaneously, private sector capabilities to provide SSA data products and services have grown significantly. The Space Data Association (SDA), a non-profit organization created by three major commercial satellite operators in 2009, has grown to include most of the major GEO satellite operators and its Space Data Center (SDC) provides SDA members with a range of services. These services include augmenting the close approach warnings provided by the 18 SPCS to take into account a satellite operator's own satellite trajectories and planned maneuvers, and assistance in resolving radio frequency interference (RFI).

On the positive side, the DOD has recently implemented a significant change to its policy for withholding information about national security space objects and activities. In my 2014 testimony, I highlighted how the culture of secrecy was partly responsible for the lack of progress on improving SSA, so this change is a welcome step forward. The U.S. military has removed the "no elements available" tag for approximately 200 objects and has started releasing

[39] Details on U.S. Strategic Command's SSA Sharing Agreements can be found here: https://www.stratcom.mil/Media/News/News-Article-View/Article/1825882/100th-space-sharing-agreement-signed-romania-space-agency-joins/

orbital data for some of them, although the rollout has been slow and some of the newly released are getting very infrequent updates.[40]

Commercial SSA companies have also entered the sector over the last decade. The announcement of the Analytical Graphics, Inc. (AGI) Commercial Space Operations Center (ComSpOC) in 2014 was just the first of several major developments. Today, companies such as AGI, ExoAnalytic and LeoLabs operate independent networks of ground-based telescopes and radars, while other companies such as SpaceNav offer sophisticated mission planning and decision analysis tools. While some of these commercial offerings are better than those provided by the 18 SPCS in specific areas, no single commercial entity can yet replicate the entire 18 SPCS mission. However, it is likely that the ability of these commercial companies to maintain a catalog of space objects and provide useful close approach warnings will exceed that of the U.S. military within the next five years.

There are three unresolved public policy issues with regard to the development of the commercial SSA sector. The first is how the U.S. government engages or competes with these commercial SSA providers. To date, the U.S. government has only engaged in small, limited contracts with commercial SSA providers while spending more than $1 billion a year on government SSA programs. The lack of government purchases and widespread availability of free government-provided data and services is having a deleterious effect on the growth and sustainability of commercial SSA industry. **Existing policy guidance directing federal agencies and departments to refrain from competing with the commercial sector and to leverage commercial products and services to the maximum extent possible should be enforced for SSA.**

Greater cooperation and utilization of commercial SSA data also leads to the second unresolved policy issue – whether SSA data and services are a public good.[41] While leveraging commercial products and services can result in more innovation and lower costs, it introduces challenges on making the data or products derived from commercial data available to all stakeholders and users. Satellite operators and governments may be able to afford to purchase commercial products, but university CubeSat operators, scientists and academic researchers, non-profits and charities, and other non-commercial entities likely cannot. Moreover, keeping data locked away behind paywalls prevents widespread data pooling and analysis that could yield new insights and innovations. **The U.S. government needs to conduct an economic goods analysis of SSA data products and services and determine how to ensure all users and stakeholders have access while maximizing collaboration and innovation.** In doing so, there may be important lessons

[40] At the time of writing, 170 of the 200 objects still did not have data, according to a list maintained by TS Kelso on the Celestrak website at https://celestrak.com/satcat/pending.php. A few of the objects for which orbital data is being released have not been updated for weeks and one for over a month.

[41] For a more in-depth economic goods analysis of SSA and the potential role of the government, see https://swfound.org/media/206172/frierson_economics_of_ssa_may2018.pdf

to be learned from the weather and remote sensing fields, which are grappling with some of the same issues.[42]

The third major public policy issue with commercial SSA is the current restrictions on on-orbit SSA. While ground-based SSA collection does not require a license, space-based SSA collection falls under remote sensing regulations. Historically, the U.S. government has prohibited any space-to-space remote sensing for national security reasons, but a policy change begun under the Obama Administration and approved by the Trump Administration now allows a limited amount of so-called "non-Earth imaging (NEI)" for U.S. commercial remote sensing licensees. However, there are still significant restrictions that hinder the development of U.S. commercial SSA capabilities for satellite inspection, anomaly resolution, and space safety that do not apply for foreign competitors.[43] **The U.S. government should ensure that only the most minimal restrictions necessary are applied to NEI in order to foster growth and innovation in commercial capabilities.**

An important consideration to keep in mind is that SSA is not something that any one entity can do entirely by itself. This is because SSA requires combining data from a large number of geographically distributed sensors on Earth and in space with operator data on precise locations and upcoming maneuvers. SSA also has many different commercial, civil, and national security applications that are unlikely to be fulfilled by a single entity. Moreover, it is unlikely that any one entity, governmental or private sector, will be trusted enough by all space actors to serve as a single, global SSA provider. Instead, I see SSA evolving to a model where there are multiple data providers that act as hubs, each serving a set of trusted users. The key element of the hubs model is the degree of cooperation and data sharing between the hubs.

In May 2014, this subcommittee held a hearing on SSA and STM in which I was also privileged to testify. In that hearing, my main recommendation was that the civil and safety-related parts of the SSA mission be transferred away from the DOD and to a federal civil agency. This recommendation was driven by the need to improve trust and transparency in civil SSA products and services and the inability of the DOD to improve its SSA computer systems or integrate data from non-traditional sources. It would also enable the DOD to refocus its efforts on detecting and countering threats to U.S. national security space systems.

At the time, there was an on-going debate within the Obama Administration on whether to assign responsibility for the civil SSA mission to the Department of Transportation (DOT) or

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[42] See https://spacenews.com/noaa-smallsat/

[43] For a more in-depth discussion of the restrictions and their impacts, see https://swfound.org/media/206172/frierson_economics_of_ssa_may2018.pdf

Department of Commerce (DOC).[44] Each department had their strengths and weaknesses and likely could have taken on the mission. The Obama Administration was leaning towards DOT, and as part of its preparatory activities the Office of Commercial Space Transportation (AST) in the FAA initiated outside studies on how it might implement a civil SSA mission.[45] FAA/AST requested FY18 funding to begin a civil SSA pilot program,[46] which was subsequently appropriated by Congress,[47] they also received FY17 funding for an initial pilot program in partnership with the DOD.[48] However, no formal policy decision giving civil SSA responsibility to DOT was issued by the end of the Obama Administration and in December 2017 AST was directed to cease its preparatory efforts pending a policy review by the Trump Administration.

As previously mentioned, the Trump Administration did indeed conduct their own interagency policy review and published the first U.S. national policy on STM in June 2018 as SPD-3. SPD-3 is very thorough and covers many of the issues addressed in the holistic picture of space sustainability outlined earlier, including updating orbital debris mitigation standards, advancing SSA and STM technology, and developing best practices, norms of behavior, and standards to enhance the safety of space activities. Much of what is in SPD-3 is non-partisan and stems from the preparatory work previously done by the Obama Administration.

The biggest policy change made by SPD-3 is to task DOC, instead of DOT, with responsibility for civil SSA and STM. Under SPD-3, DOC would assume greater authority for licensing and oversight of private sector space activities to address the aforementioned gap in existing authorities between NOAA, the FAA, and FCC. DOC would also assume responsibility for providing the civil and safety-related SSA products and services currently provided by the DOD and develop enhanced future capabilities by fusing data from commercial, scientific, and international sources. As part of this implementation, the Trump Administration has asked Congress to elevate the NOAA Office of Space Commerce (OSC) to become the Bureau of Space Commerce and increase its budget to $10 million annually.

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[44] More details on the Obama Administration's interagency process on STM can be found in Chapter 7 of my Ph.D. Dissertation: https://cpb-us-e1.wpmucdn.com/blogs.gwu.edu/dist/7/314/files/2018/03/Weeden-Dissertation-Final-11Jan2017-1p9swcp.pdf

[45] A study done by the Science and Technology Policy Institute on how DOT might establish civil SSA and STM capabilities, including leveraging commercial capabilities, can be found here: https://www.ida.org/-/media/feature/publications/e/ev/evaluating-options-for-civil-space-situational-awareness-ssa/p-8038.ashx

[46] The funding for the civil SSA pilot program was included on pg. 110 of the DOT's FY18 budget request found here: https://cms8.dot.gov/sites/dot.gov/files/docs/mission/budget/281191/faa-fy-2018-cj-final.pdf

[47] Appropriations for the DOT civil SSA pilot program were included in the 2018 Consolidated Appropriations Act, which can be found here: https://www.congress.gov/bill/115th-congress/house-bill/1625/text

[48] A discussion of the DOD's participation in the DOT civil SSA pilot program can be found on pg. 4 of Lt.Gen Buck's testimony before the House Subcommittee on Strategic Forces in May 2017: https://docs.house.gov/meetings/AS/AS29/20170519/105974/HHRG-115-AS29-Wstate-BuckD-20170519.pdf

While DOC, and OSC specifically, has taken some steps in this direction, most of the changes directed by SPD-3 have not yet been implemented due to lack of changes to their authorities and appropriations by Congress. DOC and OSC have initiated RFIs to determine what commercial SSA capabilities are available, organized reviews of existing space-related standards and norms, and established a landing team to begin coordination with the 18 SPCS. However, the full suite of actions directed by SPD-3 require a change to OSC's authorities and increased budget, steps that only Congress can take.

During the previous 115th Congress, both the House and Senate addressed the SSA issues through legislation, although in contradictory fashion. In June 2018, the House Committee on Science, Space, and Technology introduced the American Space SAFE Management Act that largely would have implemented everything in SPD-3,[49] while in July 2018 the Senate Committee on Commerce, Science, and Transportation introduced the Space Frontier Act that would have reinforced the role of FAA/AST in oversight of new and emerging space activities via a concept called mission authorization.[50] The Senate was silent on SSA authorities, reportedly out of a desire to not go against White House policy, but there are indications they favored that mission going to FAA/AST as well. Neither effort passed both chambers to become law.

During the current Congress, the Senate Committee on Commerce, Science, and Transportation has reintroduced the Space Frontier Act of 2019, which would elevate OSC to a Bureau of Space Commerce and provide it some additional authority, but is silent on SSA.[51] OSC also received a small budget increase to $2.3 million in FY20, instead of the $10 million they requested.[52]

I urge Congress to implement either the Administration's proposal under SPD-3 or an alternative solution as soon as possible. The swiftest solution would be to implement SPD-3 and give the necessary authorities and budget to OSC while elevating it to the Bureau of Space Commerce. This is the quickest path to improving U.S. civil SSA capabilities and laying the foundation for a future STM regime.

However, if a direct implementation of SPD-3 is impossible, the next best solution would be to implement a compromise that splits responsibilities between DOC and DOT, as I outlined in an

[49] Text of the 2018 American Space SAFE Management Act introduced in the House can be found here: https://www.congress.gov/bill/115th-congress/house-bill/6226

[50] Text of the 2018 Space Frontier Act introduced in the Senate can be found here: https://www.congress.gov/bill/115th-congress/senate-bill/3277

[51] Text of the 2019 Space Frontier Act introduced in the Senate can be found here: https://www.congress.gov/bill/116th-congress/senate-bill/919

[52] https://www.appropriations.senate.gov/imo/media/doc/HR%201158%20-%20SOM%20FY20.pdf

op-ed in March 2019.[53] Creating a Bureau of Space Commerce that is the lead agency for promoting commercial space and advocating for industry within the government is an excellent idea. But to bridge the divide, I propose giving responsibility for providing civil SSA data and services, creating safety standards for on-orbit space activities, and managing the air-space traffic interface to the DOT. Doing so would also make it easier to address the concerns over how the rapid increase in commercial space launches may cause disruptions to commercial aviation. These responsibilities should be given to a new Bureau of Space Transportation within DOT, created by elevating AST out of the FAA. Creating a separate bureau allows for a stronger focus on space, better resourcing, and more independence from the FAA and their overwhelming focus on aviation.

I believe there is also a role for NASA to play in leading the research and development of new technologies to improve SSA. While the commercial sector is already innovating to a certain degree, there is still a strong need for research into future technologies to improve SSA and tackle emerging challenges such as large constellations, tracking and identification of CubeSats, and increasing the accuracy of conjunction assessments. NASA's efforts in this area should not be aimed at developing or operating new government capabilities, but rather in enhancing and enabling technological development that can be deployed by the private sector.

A related and important policy issue is assigning authority for space environmental management in order to incent progress on remediation. This is necessary because even with the policy changes directed by SPD-3, there is no federal agency or department that has managing the space environment, including orbital debris removal, as part of its mission. As discussed earlier, this is a critical prerequisite to making progress on implementing the policy directive to create such a capability and begin to remove existing orbital debris. As with STM authority, there are multiple options for where this authority should go and no single agency or department stands out as the overwhelming favorite. DOT, DOC, and NASA are all potential options and the choice will likely depend on how the broader compromise for STM and mission authorization plays out.

The main hurdle to overcome in Congressional action on this issue is the disparate committees and subcommittees with jurisdiction. At the moment, there are at least ten Congressional committees and subcommittees that have at least partial jurisdiction over the various civil, commercial, national security, authorization, and appropriations aspects of these issues. There is no easy solution to this problem, other than to suggest the professional staff of these various committees begin consultations to establish a common understanding of the importance of SSA and STM that could lead to coordinated legislation.

[53] https://www.thespacereview.com/article/3673/1

5. Conclusion

It is critical that Congress act on this issue now. SSA is fundamental to everything the United States does in space, and the benefits derived from such activities. This includes protecting human exploration and science, ensuring critical weather and climate data, protecting important national security capabilities, and enabling economic growth and innovation in the commercial space sector.

The huge amount of change the space domain is currently experiencing across civil, commercial, and national security sectors only adds to the salience and timeliness of this issue. Current SSA capabilities were being stretched six years ago; today they are dangerously insufficient to deal with the emerging challenges from the growing number of space actors, large constellations, orbital debris hazards, and a more complex and competitive geopolitical environment.

Action from Congress should focus on implementing a federal civil SSA agency that has the required regulatory authorities and is appropriately resourced. That agency should be tasked to leverage commercial and international capabilities to build a civil SSA system that can meet the safety challenges of today and lay the foundation for the STM regime of tomorrow. Doing so will take a giant step toward ensuring the long-term sustainability of space activities for the United States and all space actors, and that humanity can continue to utilize space for benefits on Earth.

Biography for Dr. Brian Weeden

Dr. Brian Weeden is the Director of Program Planning for Secure World Foundation and has nearly two decades of professional experience in space operations and policy.

Dr. Weeden directs strategic planning for future-year projects to meet the Foundation's goals and objectives, and conducts research on space debris, global space situational awareness, space traffic management, protection of space assets, and space governance. Dr. Weeden also organizes national and international workshops to increase awareness of and facilitate dialogue on space security, stability, and sustainability topics. He is a member and former Chair of the World Economic Forum's Global Future Council on Space Technologies, a member of the Advisory Committee on Commercial Remote Sensing (ACCRES) to the National Oceanic and Atmospheric Administration (NOAA), and the Executive Director of the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS).

Prior to joining SWF, Dr. Weeden served nine years on active duty as an officer in the United States Air Force working in space and intercontinental ballistic missile (ICBM) operations. As part of U.S. Strategic Command's Joint Space Operations Center (JSpOC), Dr. Weeden directed the orbital analyst training program and developed tactics, techniques and procedures for improving space situational awareness.

Respected and recognized as an international expert, Dr. Weeden's research and analysis have been featured in The New York Times, The Washington Post, National Public Radio, USA Today, The BBC, Fox News, China Radio International, The Economist, The World Economic Forum's Annual Meeting in Davos, academic journals, presentations to the United Nations, and testimony before the U.S. Congress. Read Dr. Weeden's publications.

Dr. Weeden holds a Bachelor of Science Degree in Electrical Engineering from Clarkson University, a Master of Science Degree in Space Studies from the University of North Dakota, and is also a graduate of the International Space University Space Studies Program (2007, Beijing). He has a PhD in Public Policy and Public Administration from George Washington University in the field of Science and Technology Policy.