HENRY M. JACKSON SCHOOL
OF INTERNATIONAL STUDIES
UNIVERSITY of WASHINGTON

PREVENTING DISASTERS IN SPACE

Proposing CODA:
Committee on Orbital Debris Affairs

TASK FORCE 2022

The Donald C. Hellmann Task Force Program

Preventing Disasters in Outer Space
Proposing CODA: Committee on Orbital Debris Affairs

Task Force Report, Spring 2022

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Abbreviations and Acronyms

ACCRES	Advisory Committee on Commercial Remote Sensing
ADR	Active Debris Removal
ANSI	American National Standards Institute
ARES	Astromaterials Research and Exploration Science
ASAT	Anti-Satellite Weapon
AST	Office of Commercial Space Transportation
CCSDS	Consultative Committee for Space Data Systems
CFIUS	Committee on Foreign Investment in the United States
CFR	Code of Federal Regulations
CFSCC	Combined Force Space Component Command
CODA	Committee on Orbital Debris Affairs
COPUOS	Committee on the Peaceful Uses of Outer Space
CRSRA	Commercial Remote Sensing Regulatory Affairs
DiRAC	Institute for Data Intensive Research in Astrophysics and Cosmology
ESA	European Space Agency
ESC	Office of Emerging Security Challenges
FAA	Federal Aviation Administration
FAR	Federal Acquisition Regulation
FCC	Federal Communications Commission
FFRDC	Federally Funded Research and Development Centers
GEOINT	Geospatial Intelligence
GEO	Geostationary Orbit
GSTC	Global Space Traffic Coordination
IADC	Inter-Agency Space Debris Coordination
IISL	International Institute of Space Law
IOS	In-Orbit Services
ISO	International Standards Organization
ISR	Intelligence, Surveillance, and Reconnaissance
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
JTF-SD	Joint Task Force–Space Defense
LEO	Lower-Earth Orbit
MOU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
NAPA	National Academy of Public Administration
NDSA	National Defense Space Architecture
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation

NSpC	National Space Council
NTIA	National Telecommunications and Information Administration
OADR	Open-Architecture Data Repository
ODMSP	Orbital Debris Mitigation Standard Practices
ODPO	Orbital Debris Program Office
ODRAD IWG	Orbital Debris Research and Development Interagency Working Group
OES/SA	Office of Space Affairs
OES/SAT	Office of Space and Advanced Technology
OMM	Orbit Mean-Elements Message
OSAM	On-Orbit Repair, Assembly, and Manufacturing
PLA	People's Liberation Army
PNT	Positioning, Navigation, and Timing
R&D	Research and Development
SDA	Space Data Association
SDA	Space Development Agency
SDA	Space Domain Awareness
SIGINT	Signals Intelligence
SLDP	Space Law, Data and Policy Program
SPD-3	Space Policy Directive-3
SSA	Space Situational Awareness
STM	Space Traffic Management
UNOOSA	United Nations Office for Outer Space Affairs
US	United States
USG	United States Government
USSF	United States Space Force
USSPACECOM	United States Space Command
UTA	University of Texas at Austin
UW	University of Washington
UW SDI	University of Washington Space Data Institute

Executive Summary

The United States has long been involved in outer space exploration and innovation, acting as a world leader in these domains. Currently, orbital debris poses a significant threat to the future of the US presence in space and thus is an issue that must be addressed with a coordinated national response. In the following report we will be introducing the issue posed by orbital debris and how this pertains to a larger institutional problem. We will then recommend an integrated policy recommendation comprised of public, private, and educational sectors which follow a three-tier system.

What Challenges Are We Facing?

In the last 65 years, since the commencement of the first international space race, manmade objects known as orbital debris have been accumulating in Earth's outer atmospheric layers and beyond. There are over 27,000 trackable units of orbital debris polluting near-Earth space, which can travel at speeds up to 17,500 mph.[1] The damage inflicted by even small pieces of debris moving at these speeds can be detrimental to anything on the receiving end of a strike. Containing a combined mass of over 9,300 tons of debris, the domains of low-Earth orbit (LEO) and geostationary orbit (GEO) have become astral junkyards.[2] Given the culmination of debris in LEO and GEO, the environment for modern space affairs has become too volatile to maintain present orbital technology safely, and to continue sending technology into space.

[1] Mark Garcia, "Space Debris and Human Spacecraft," Text, NASA, April 13, 2015, http://www.nasa.gov/mission_pages/station/news/orbital_debris.html.
[2] "About Space Debris," accessed May 9, 2022, https://www.esa.int/Safety_Security/Space_Debris/About_space_debris.

Our problem lies in the lack of a coordinated institutional response to address this growing danger in space. Despite numerous domestic space domain agencies like NASA, the US Space Command (USSPACECOM), the National Space Council (NSpC), and many others, there has not yet been an integrated national solution formulated regarding the issue of space debris.

We acknowledge the great efforts made by individual United States government agencies, offices, and regulatory bodies to address the mitigation of orbital debris. However, maximum effectiveness will only be plausible through synchronous methods. Therefore, it is critical that our fight for safety and agency in space is brought down to Earth and solved first on a united, federal level.

What Is Our Response?

In order to prevent further disasters in outer space, the United States must continue its path of global leadership and become the cornerstone of modern space domain problem-solving. We have written the following policy to address what we believe will be the most successful way to approach the lack of integrated response to the orbital debris problem. Our policy recommendation involves an interagency committee within the Federal Communications Commission (FCC), which will function as an Advisory Committee established under the Federal Advisory Committee Act (FACA). Our interagency committee will consist of public, private, and educational sectors and will be tasked with organizing pre-existing institutions through data collection, data organization, and regulatory policy recommendations to the FCC. This will allow the US to better address the multifaceted issue of orbital debris containment and mitigation.

The committee will build upon current efforts being made by the Orbital Debris Research and Development Interagency Working Group (ODRAD IWG).

There will be three primary elements that we suggest our interagency committee act on:

- Establishing an additional FFRDC in partnership with NASA with objectives to lead in the development of space debris mitigation disciplines, institute data organization programs, and recommend rules, regulations, and definitions to protect US assets in space.
- Championing domestic entities to specialize in orbital debris data collection through a federal partnership to solidify and promote US leadership as a hub for the commercial space industry.
- Leading a multinational collaboration with objectives to continue expanding and updating USSPACECOM's Space Situational/Domain Awareness (SSA/SDA) program, help transition its operational control to the Department of Commerce, and use it as a platform to share definitions, standards, and norms.

By founding our proposed committee, the United States will not only be able to create an environment safer for all future space exploration and innovation but also reaffirm its top international standing and become a model for all future space affairs.

TABLE OF CONTENTS

TABLE OF FIGURES

The Problem of Orbital Debris

In October of 1957, the first international space race commenced with the Soviet Union's launch of Sputnik-I, the world's first official satellite.[3] It was at this point the United States began its undertaking of the global competition, investing domestic resources into the research and development of outer space exploration technologies. Then in 1969, the United States achieved a victory in the space race with Apollo 11's lunar landing and Neil Armstrong's first steps on the moon.[4] With this historic triumph, the United States has built and solidified its place as a leader in space exploration.

Today, the United States is faced with a new global space race — the "Counterspace Race" — which revolves around the influx of manmade objects in space known as orbital debris.[5] In recent years, numerous countries have begun to invest in the research and development of space junk removal technologies. However, these technologies are dual-use, meaning they may be used to counter orbital debris or serve military purposes. Due to their potential use as military tools such as lasers and aerial hunter systems, dual-use technologies pose a high-security threat to all actors in space. This has led to a space race that reflects the turbulence of current geopolitics and has nations like the United States, China, Russia, India, and Japan "attempting to shift the balances of space power in their favor".[6]

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[3] Andrew Chatzky, Anshu Siripurapu, and Steven Markovich, "Space Exploration and U.S. Competitiveness," Council on Foreign Relations, September 23, 2021, 0, https://www.cfr.org/backgrounder/space-exploration-and-us-competitiveness.

[4] Maddie Davis, "The Space Race," Miller Center, September 11, 2020, https://millercenter.org/the-presidency/educational-resources/space-race.

[5] Saadia Pekkanen, "Why Space Debris Cleanup Might Be a National Security Threat," The Conversation, November 13, 2018, https://theconversation.com/amp/why-space-debris-cleanup-might-be-a-national-security-threat-105816.

[6] Saadia Pekkanen, "Governing the New Space Race," *American Journal of International Law* 113 (ed 2019): 92–97, https://doi.org/10.1017/aju.2019.16.

Orbital debris is defined by the Interagency Space Debris Coordination (IADC) Space Debris Mitigation Guidelines, as "all man-made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional." This means that orbital debris consists of anything ranging from an entire de-commissioned satellite to metal scraps from technological collisions and even flecks of chipped paint from rocket bodies.[7] As aforementioned, there are currently over 27,000 units of trackable orbital debris residing in LEO and GEO [Figure 1]. The USG tracks these units through the Department of Defense's worldwide Space Surveillance Network (SSN). However, this number may not account for debris smaller than 10 cm and continues to proliferate as collisions occur.

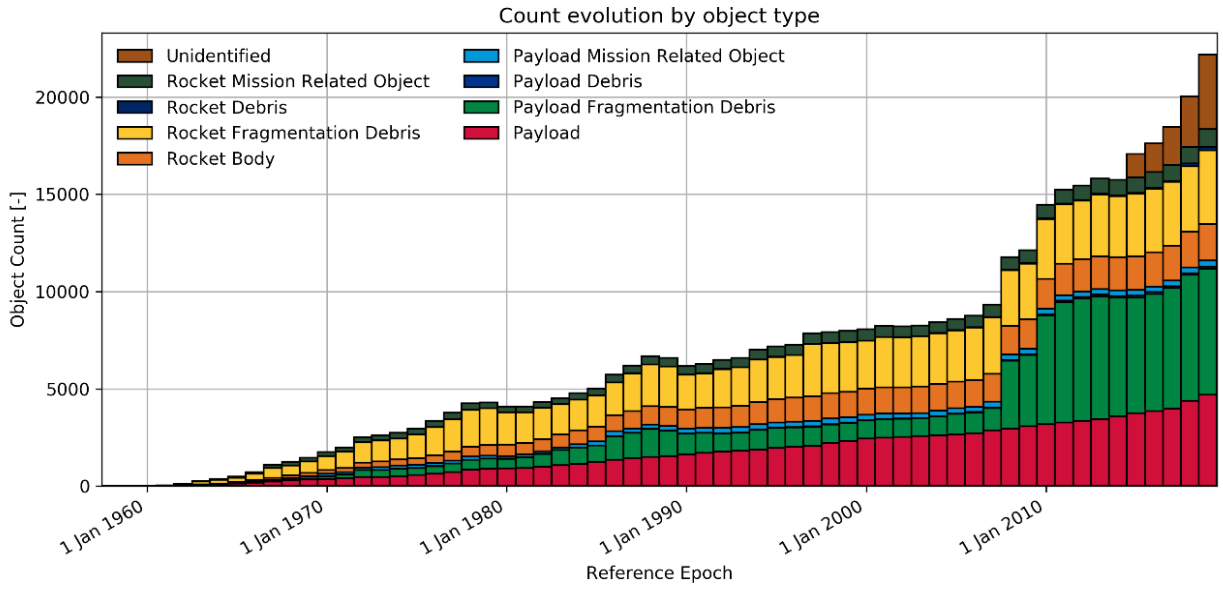

Figure 1 - [Chart of Objects in Space][8]

Even the smallest fragments of orbital debris can cause irreversible damage to space technologies. Given the high speeds and unpredictability of movements in space, natural debris

[7] Jennifer Wall : Wall, "What Is Orbital Debris?," NASA (Brian Dunbar, June 1, 2015), http://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-orbital-debris-58.html.
[8] "About Space Debris."

(like meteoroids), as well as manmade debris and still operating technologies can often collide.[9] At least 17 satellite collisions have occurred in recent years.[10] This process leads to a cycle of orbital debris creation. The destruction of a single large US spy satellite has the potential to double the quantity of orbital debris in lower Earth orbit.[11]

In addition to accidental debris impacts, numerous countries have conducted kinetic anti-satellite weapon (ASAT) tests. The testing of these kinetic ASATs destroys old or inactive satellites. Such tests create thousands of debris fragments that can remain in LEO for many years. The only way to orchestrate such tests without this result is if they are conducted at such a low altitude that the resulting fragments quickly re-enter the Earth's atmosphere and burn up. Unfortunately, this is not common practice.

Many leaders in the space industry, including the US, China, Russia, and India have tested kinetic-kill ASAT tests with varying outcomes. Subsequently, most of these tests significantly increased the number of orbital debris in LEO, while only a handful of other tests allowed debris to be burned up upon re-entry.[12] In 2007, a Chinese ASAT test created the largest ever number of trackable space debris objects (above 10 centimeters in diameter). This was mainly because the target satellite was orbiting at a high altitude (800 kilometers) above

[9] Garcia, "Space Debris and Human Spacecraft."
[10] Daniel L. Oltrogge and Salvatore Alfano, "The Technical Challenges of Better Space Situational Awareness and Space Traffic Management," *Journal of Space Safety Engineering*, Space Traffic Management and Space Situational Awareness, 6, no. 2 (June 1, 2019): 72–79, https://doi.org/10.1016/j.jsse.2019.05.004.
[11] David Wright, "Space Debris from Anti-Satellite Weapons" (UCSUSA, April 2008), https://www.ucsusa.org/sites/default/files/2019-09/debris-in-brief-factsheet.pdf.
[12] Norton A. Schwartz et al., "Orbital Debris and Kinetic Anti-Satellite Concerns: How a 'Kessler Syndrome' Threatens U.S. Use of Space Assets" (Institute for Defense Analyses, 2021), https://www.jstor.org/stable/resrep30922.

the Earth. The incentive to end kinetic ASAT testing continues to increase as the danger of accumulating thousands of additional space debris units rises.

On April 18th, 2022, Vice President Kamala Harris gave a speech at Vandenberg Space Force Base in which she announced that the US has unilaterally ruled out further Earth-based kinetic ASAT tests.[13] This marks the United States as the first ever nation to authorize the suspension of direct-ascent anti-satellite weapons testing. However, given that the US is one of the only nations to make this stride, the risk of collision continues to grow.

Orbital debris poses both financial and security threats to the United States. At 61%, the United States owns the majority of the world's active satellites. As the risk of orbital collision increases, so does the risk of the loss of vital data that our satellites provide. Additionally, the destruction of satellites would be a great financial loss for the United States government. Liability enforcement is difficult to regulate and can shift financial burdens onto nations when no claims are made regarding the destruction of space technologies.[14]

Moreover, the congestion of orbital debris causes environmental damage which affects the sustainability of commercial, civic, and military activity in space. There is a case to be made for considering the orbital space around Earth as another one of our ecosystems that requires the same care, concerns, and regulations as other Earth ecosystems.[15, 16]

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[13] Amanda Miller, "Biden Administration Says U.S. Won't Test Certain Anti-Satellite Weapons," *Air Force Magazine* (blog), April 19, 2022, https://www.airforcemag.com/biden-administration-says-u-s-wont-test-certain-anti-satellite-weapons/.

[14] Paul B. Larsen, "Commercial Operator Liability in the New Space Era," *American Journal of International Law* 113 (ed 2019): 109–13, https://doi.org/10.1017/aju.2019.18.

[15] Shell bound by the Karman line at a height of ~80–100 km above the Earth's surface and geosynchronous orbit at ~36,000 km

[16] Andy Lawrence et al., "The Case for Space Environmentalism," *Nature Astronomy* 6, no. 4 (April 2022): 428–35, https://doi.org/10.1038/s41550-022-01655-6.

If the United States wants to keep intact its economic and security ties to current space ventures and continue to strive for further innovation and exploration in space, it is integral that we begin working towards a goal of orbital debris mitigation.

Uncoordinated US Responses

The Public Sector

There are currently 17 principal government agencies, offices, and/or regulatory bodies within the United States involved in space policy and regulation [Figure 2].

Figure 2 - [Map of US Space Bodies]

National Aeronautics and Space Administration (NASA): ODPO

The US began its domestic regulatory position on space in 1958 with the signing and implementation of the National Aeronautics and Space Act.[17] The National Aeronautics and Space Administration (NASA) has become an independent agency of the US federal government

[17] "National Aeronautics and Space Act of 1958," Pub. L. No. 85–568, 12575 H.R. (1958), https://www.govtrack.us/congress/bills/85/hr12575/text.

that stands as a global leader in space exploration and research. It is responsible for the US civilian space program and in doing so, its attention spans a wide range of topics, including orbital debris.[18] It does not regulate space activity but instead can provide analysis to entities that do.[19]

Orbital Debris Response: Creation of the Orbital Debris Program Office (ODPO)

Within the Astromaterials Research and Exploration Science (ARES) division of NASA sits its Orbital Debris Program Office (ODPO). The ODPO is tasked with conducting measurements of the orbital environment and developing technological consensus on what orbital debris mitigation methods should be adopted for the users of said orbital environment. The ODPO and its parent organization, have published the *NASA Procedural Requirements for Limiting Orbital Debris, the Process for Limiting Orbital Debris, the Handbook for Limiting Orbital Debris, the History of On-Orbit Satellite Fragmentations, and the US Government Orbital Debris Mitigation Standard Practices* in response to orbital debris.[20]

US Department of Defense (DoD): Assistant Secretary of Defense for Homeland Defense and Global Security, USSF, USSPACECOM, SDA

Within the US Department of Defense (DoD), there is the Assistant Secretary of Defense for Homeland Defense and Global Security, US Space Force, US Space Command, and the Space Development Agency. The Assistant Secretary of Defense for Homeland Defense and Global Security is tasked with providing policy guidance on space warfighting and national security

[18] Sarah Loff, "About NASA," Text, NASA, January 28, 2015, http://www.nasa.gov/about/index.html.
[19] Therese Jones, "Navigating Government Space Policy" (University of Washington, April 6, 2021), https://drive.google.com/file/d/1BqdZD4bCSDCgbsRA09408Hriw2UHxEbz/view.
[20] "ARES | Orbital Debris Program Office | Reference Documents," accessed May 9, 2022, https://orbitaldebris.jsc.nasa.gov/reference-documents/.

advantages.[21] This position was created in 2003. The US Space Force (USSF) was founded recently in 2019, as the space services branch of the US Armed Forces.[22] US Space Command (USSPACECOM) is a combatant command formed in 1985, removed in 2002, and then revived in 2019. USSPACECOM employs assigned forces from each service branch for missions in the space domain. It conducts operations in, from, and to space to deter conflict, defeat aggression, deliver space combat power, and defend US interests with allies and partners. The Space Development Agency (SDA), not to be confused with Space Domain Awareness or the Space Data Association, both using the same acronyms, was founded in 2019 and operates the National Defense Space Architecture.[23]

Orbital Debris Response: SSA Tracking and Funding

Space Situational Awareness (SSA) and Space Domain Awareness (SDA) refer to how objects in orbit like satellites are monitored and tracked. This is done mostly through ground-level infrastructures such as tracking radars, detection radars, or other monitoring equipment. This data is then stored in a database and updated at consistent intervals. The difference between SSA and SDA lies in intent. As stated by Gen. James H. Dickinson, SSA is the tracking of space objects in general while SDA is more focused on finding the motive behind the object.[24] However, outside of intent, it is generally the same. The USSPACECOM program will be referred

[21] "Assistant Secretary of Defense for Homeland Defense and Global Security," accessed May 9, 2022, https://policy.defense.gov/OUSDP-Offices/ASD-HDGS/.
[22] "Mission," accessed May 9, 2022, https://www.spaceforce.mil/About-Us/About-Space-Force/Mission/.
[23] "Who We Are – Space Development Agency," accessed May 9, 2022, https://www.sda.mil/home/who-we-are/.
[24] Amanda Miller, "Ground-Based Radars, New Cislunar Data Agreement to Further Space Domain Awareness," *Air Force Magazine* (blog), February 23, 2022, https://www.airforcemag.com/ground-based-radars-new-data-agreement-space-domain-awareness/.

to as SSA when in reference to the sharing program, and SSA/SDA when discussing DoD-internal use of the data.

The US currently manages its SSA/SDA data through the Space Track program, operated by the 18th Space Defense Squadron under USSPACECOM.[25] The DoD maintains this database of satellites, known as the Space Object Catalog, and is updated by the Space Track SSA program through the Space Surveillance Network. Data is provided within three separate tiers.[26] The first is Basic Services, simply providing basic information on satellite positions. Anyone can access this information given they have a valid account on Space-Track.org. The second tier is Emergency Services, geared towards those who operate satellites. This level gives users information about close approaching satellites through Basic Emergency Conjunction Assessments, as well as assistance in collision avoidance through Basic Emergency Collision Avoidance. The last tier is Advance Services, requiring an SSA Sharing Agreement signed with USSPACECOM. This agreement contains the rules and regulations of the shared data, as well as ensures that this data will be used to "facilitate ongoing cooperation and advance spaceflight safety." Many more intensive services are provided, such as Launch Conjunction Assessments, Early Orbit Conjunction Assessments, as well as advanced versions of the services provided to the Emergency Services tier.

[25] "18th Space Defense Squadron," Peterson Space Force Base, September 22, 2020, https://www.peterson.spaceforce.mil/About-Us/Fact-Sheets/Display/Article/2356622/18th-space-defense-squadron/.
[26] "Space-Track.Org," accessed April 7, 2022, https://www.space-track.org/documentation#/odr.

As of now, USSPACECOM has signed 151 SSA Sharing Agreements.[27] As stated on the Space-Track website, the motivation for disseminating this data is to "enhance spaceflight safety, prevent potentially catastrophic orbital collisions, and increase international cooperation in space".[28] This service is vital in protecting US-origin satellites in space.

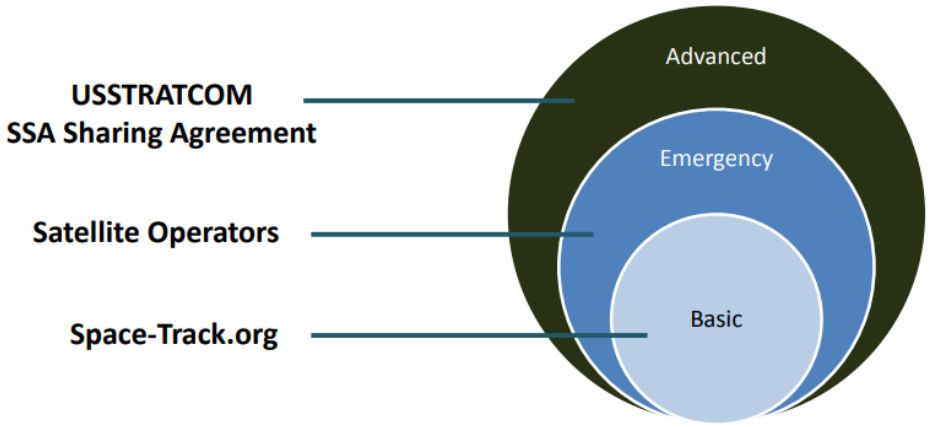

Figure 3 - [Space-Track Data Sharing Tiers][29]

However, the US is moving away from this current system as stated in Space Policy Directive-3 (SPD-3).[30] The directive instructs the Department of Commerce (DoC), instead of the DoD, to begin providing an SSA service similar to the one given by Space-Track for public and private use. The data for this will be taken from the DoD's existing catalog of tracked space objects and its SSN, where it will remain. The DoD has stated before that it wants to move away from SSA data collection[31], so this transfer of responsibility is of mutual interest between

[27] "USSPACECOM and Sweden Sign a Space Situational Awareness Sharing Agreement," United States Space Command, accessed May 2, 2022, http://www.spacecom.mil/News/Article-Display//Article/2992854/usspacecom-and-sweden-sign-a-space-situational-awareness-sharing-agreement/.
[28] "Space-Track.Org."
[29] Brian Weeden, "US Policy and Capabilities on SSA," https://swfound.org/media/206348/weeden-us-policy-and-capabilities-for-ssa.pdf.
[30] Todd Harrison and Kaitlyn Johnson, "How Does Space Policy Directive 3 Affect Space Traffic Management?," CSIS, June 19, 2018, https://www.csis.org/analysis/how-does-space-policy-directive-3-affect-space-traffic-management.
[31] Weeden, "US Policy and Capabilities on SSA."

departments. The US has also expressed interest in a Space Traffic Management system using this framework within the DoC. The DoC has already begun on an Open Architecture Data Repository (OADR) system to manage the incoming SSA data. It is anticipated that this transfer will be slow to occur. Therefore, some form of the system must be maintained as this transition takes place. This is where the current SSA program will be helpful.

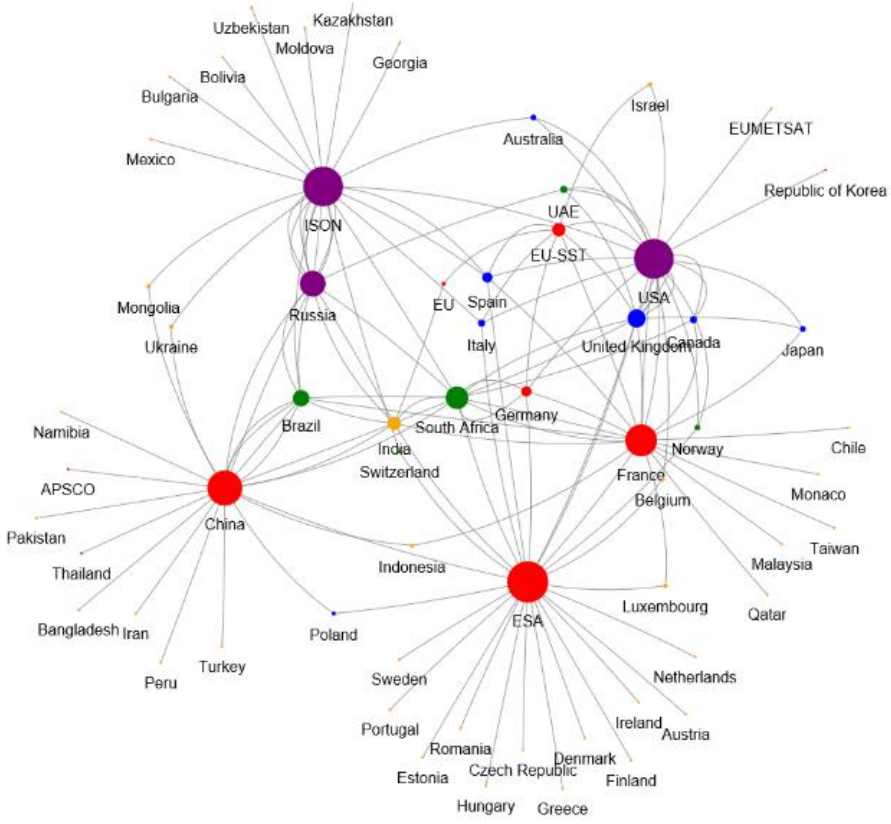

Figure 4 - [2010-2017 Partnerships on Space Activities, Particularly for SSA][32]

USSPACECOM has signed SSA Sharing Agreements with 31 nations, including but not limited to: Australia, Japan, South Korea, Brazil, France, and the United Kingdom. Agreements have also been made with two intergovernmental organizations, the European Space Agency (ESA) and

[32] Bhavya Lal et al., "Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM)" (IDA Science & Technology Policy Institute, April 2018), https://www.ida.org/-/media/feature/publications/g/gl/global-trends-in-space-situational-awareness-ssa-and-space-traffic-management-stm/d-9074.ashx.

the European Organization for the Exploitation of Meteorological Satellites, and more than 77 commercial satellite owners, operators, and launchers. This number has grown rapidly in the past 5 years, with only 11 nations having signed Sharing Agreements in 2016.[33]

The SSN collects data under USSPACECOM using ground-level monitoring equipment. This data is then used to inform its SSA program. There are varying types of sites, such as radars and telescopes. The data collection sites are located around the globe, as shown in Figure 5, with certain sites being dedicated to data collection for the SSN, and others collecting the data when not tasked with other objectives. Some of these sites are not run by USSPACECOM and instead by international partners, such as the Globus II radar operated by the Norwegian Intelligence Service. However, this kind of infrastructure is lacking in critical regions such as Africa, South America, and Asia. The majority of the SSN infrastructure is located within the US, with a few locations in Europe and Oceania.

[33] Clinton Crosier, "United States Strategic Command Space Situational Awareness Sharing Program Update," https://www.unoosa.org/documents/pdf/copuos/stsc/2017/tech-34E.pdf.

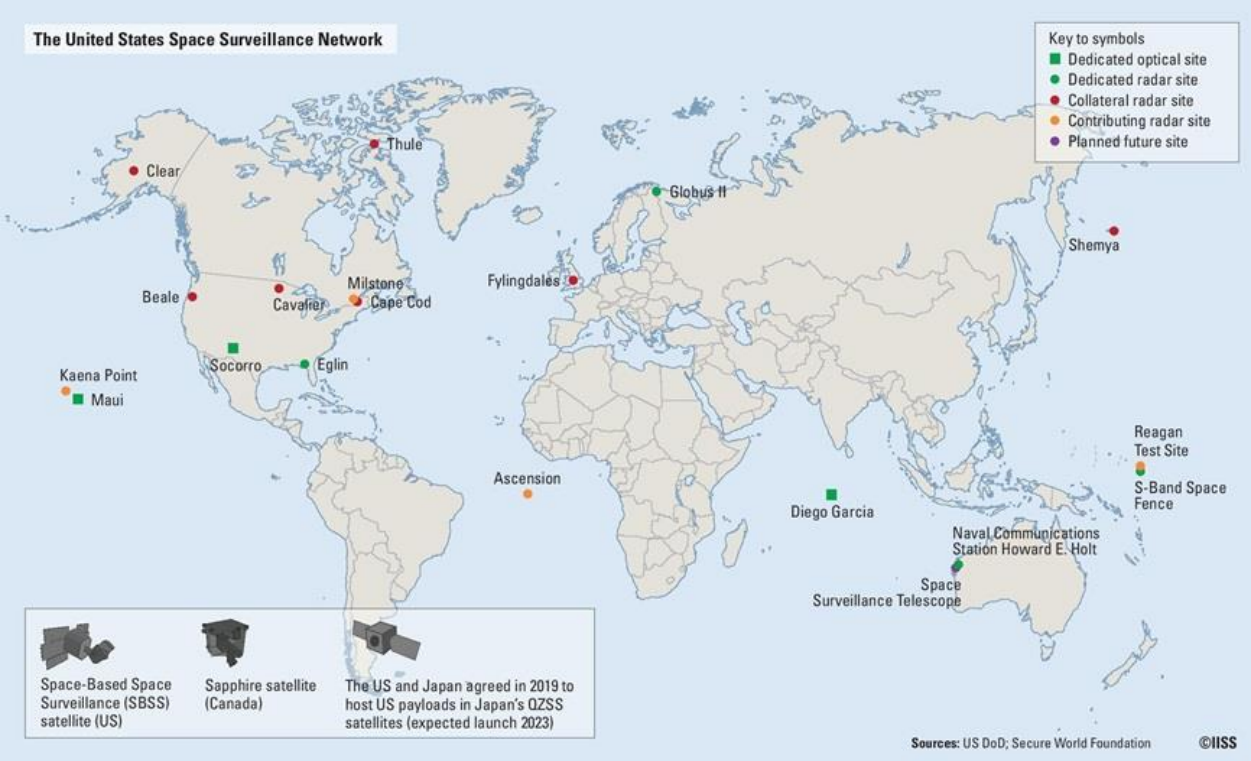

Figure 5 - [US Space Surveillance Network Sites][34]

Space Track SSA currently uses the Alpha-5 schema to number and catalog space objects. This is a stop-gap measure that just slightly modifies the previously used Two-line Element Set (TLE). This allows for the continued use of legacy systems that have not moved on from TLE, but still allows for a larger database. However, this TLE-based system still has many issues. TLE data can quickly become outdated, requiring frequent updates. It is also susceptible to errors inherent to how they are processed using the Simplified perturbations models.[35]

The Consultative Committee for Space Data Systems (CCSDS), an international organization that helps coordinate data type standards and develop norms in space data, currently

[34] Yuka Koshino, "Japan's New Space Domain Mission Unit and Security in the Indo-Pacific Region," IISS, accessed May 9, 2022, https://www.iiss.org/blogs/military-balance/2020/05/japan-space-domain-mission-unit-security.
[35] Danielle Racelis and Mathieu Joerger, "High-Integrity TLE Error Models for MEO and GEO Satellites," in *2018 AIAA SPACE and Astronautics Forum and Exposition* (American Institute of Aeronautics and Astronautics), accessed May 9, 2022, https://doi.org/10.2514/6.2018-5241.

recommends that orbital data be provided in the form of Orbit Mean-Elements Messages (OMM).[36] Large space agencies like ESA have adopted this as their data standard. As NASA is also a part of this organization, Space Track has begun providing alternate data in the OMM format on request.[37] However, it is not the standard for its data. The TLE format still is the primary type of data that the SSA program prefers to share its data in. The CCSDS prefer the OMM format as it is a more flexible data type with a form more intelligible to humans and not just computers. While there are issues with OMM's tracking of near-Earth debris fragments, it still has strong tracking and collision avoidance capabilities for non-debris objects.

US Department of Commerce (DOC): Office of Space Commerce, NESDIS, CRSRA, NTIA

Within the US Department of Commerce (DoC), agencies include NOAA's Office of Space Commerce, National Environmental Satellite, Data, and Information Service, Commercial Remote Sensing Regulatory Affairs, and the National Telecommunications and Information Administration. Established in 1988, the Office of Space Commerce coordinates with the US Department of Commerce with a mission to foster the conditions for economic growth and technological advancement of the US commercial space industry.[38] Founded in 1982, the National Environmental Satellite, Data, and Information Service (NESDIS) provides global environmental data collected from meteorological satellites to promote and protect national security, environment, economy, and quality of life.[39] Within NESDIS is Commercial Remote Sensing Regulatory Affairs (CRSRA) that licenses the operation of private Earth remote sensing

[36] "Orbit Data Messages" (Consultative Committee for Space Data Systems, November 2009), https://public.ccsds.org/Pubs/502x0b2c1e2.pdf.
[37] "Space-Track.Org."
[38] "Mission – Office of Space Commerce," accessed May 9, 2022, https://www.space.commerce.gov/about/mission/.
[39] "What We Do," NESDIS, accessed May 9, 2022, https://www.nesdis.noaa.gov/about/what-we-do.

space systems,[40] and its Advisory Committee (ACCRES), which evaluates economic, technological, and institutional developments relating to commercial remote sensing, was established in 2002.[41] Established in 1978, the National Telecommunications and Information Administration (NTIA) advises the President on telecommunications and information policy issues and regulates governmental electronic communication use.[42, 43] The Department of Commerce is the lead federal entity to, "partner with private sector and US Government stakeholders to develop and operate Open Architecture Data Repository for enhanced space situational awareness".[44]

Orbital Debris Response: OADR & Deference to FCC Licensing Requirements

Again, the DoC has begun on an OADR system to take over SSA data collection and space traffic management. Yet additionally, the DoC has stated that "to avoid duplicative regulation, Commerce has opted to defer to FCC license requirements regarding orbital debris and spacecraft disposal. Therefore, there is no longer any license condition requiring specific orbital debris or spacecraft disposal practices in this final rule".[45] Although NOAA's Office of Space Commerce has a website page dedicated to orbital debris paralleling NASA's initiative to information accessibility on the issue; this page only holds a statement from the Office of Space

[40] "Commercial Remote Sensing Regulatory Affairs," NESDIS, accessed May 9, 2022, https://www.nesdis.noaa.gov/about/our-offices/commercial-remote-sensing-regulatory-affairs.
[41] "Advisory Committee on Commercial Remote Sensing | NESDIS," accessed May 9, 2022, https://www.nesdis.noaa.gov/commercial-space/regulatory-affairs/advisory-committee-commercial-remote-sensing.
[42] "About NTIA | National Telecommunications and Information Administration," accessed May 9, 2022, https://www.ntia.doc.gov/about.
[43] Therese Jones, "Navigating Government Space Policy."
[44] Diane Howard, "Open Architecture Data Repository," https://www.unoosa.org/documents/pdf/copuos/stsc/2021/tech-55E.pdf.
[45] "15 CFR Part 960 -- Licensing of Private Remote Sensing Space Systems," accessed May 18, 2022, https://www.ecfr.gov/current/title-15/subtitle-B/chapter-IX/subchapter-D/part-960.

Commerce that they "coordinate with the Commerce Department's efforts in this (Space Policy Directive-3, 'Mitigate the effect of orbital debris on space activities.')" and snapshots of government material related to orbital debris. A similar media approach is NESDIS's release of a news story in 2018 that touches on the lethal population of orbital debris.

US Department of State (DOS): OES/SA, ESC

In the US Department of State is the Office of Space Affairs and the Office of Emerging Security Challenges. The Office of Space Affairs (OES/SA) pursues and maintains a rules-based international framework regarding space. It also leads interagency coordination on civil space international agreements.[46] The Office of Emerging Security Challenges (ESC) leads in developing State Department positions on space security and missile defense cooperation among allies and partners.[47]

Orbital Debris Response: COPUOS and IADC Diplomacy

In recent decades, various efforts have been made to promote international cooperation on initiatives to deal with debris in space. One of the earliest such efforts was the Committee on the Peaceful Uses of Outer Spaces (COPUOS), established by the UN General Assembly in 1959. COPUOS was intended to promote cooperation in the study and exploration of space, and it has tried to address legal issues arising from those activities. As of today, it has created five international treaties.[48] Another example of international cooperation is the Inter-

[46] "About Us – Office of Space Affairs - United States Department of State," accessed May 9, 2022, https://www.state.gov/about-us-office-of-space-affairs/.
[47] "Office of Emerging Security Challenges," *United States Department of State* (blog), accessed May 9, 2022, https://www.state.gov/bureaus-offices/under-secretary-for-arms-control-and-international-security-affairs/bureau-of-arms-control-verification-and-compliance/office-of-emerging-security-challenges/.
[48] "COPUOS," accessed May 18, 2022, https://www.unoosa.org/oosa/en/ourwork/copuos/index.html.

Agency Space Debris Coordination Committee (IADC), which describes its primary purposes as "to exchange information on space debris research activities between member space agencies." The IADC facilitates exchanges of information through conferences and the circulation of proposed guidelines and standard practices.

The US has played an active part in both COPUOS and IADC. In the former, it acts through the UN, while its participation in the IADC is through NASA. The US has supported the ideas expressed in UN General Assembly Resolution 75/36 which would; "[reduce] space threats through norms, rules, and principles of responsible behaviors".[49] This resolution addresses both natural and man-made orbital debris (including ASATs) as an existing potential threat and security risk to space systems. It was not long after this resolution was introduced that the US government published *National Space Priorities Framework,* reemphasizing its leadership role "...in the responsible, peaceful, and sustainable exploration and use of outer space" with regards to evolving space activities, regulations, and guidelines.[50]

On June 18th, 2018, the White House strengthened its stance by issuing Space Policy Directive-3, entitled National Space Traffic Management Policy. This presidential memorandum directs federal agencies to follow a series of principles to achieve "safety, stability, and operational sustainability" regarding orbital debris. It calls for "planning, coordination, and on-orbit synchronization of activities," including the collection of more data on trackable debris. SPD-3 also calls for developing new standard practices and a program that leads to "active

[49] "United States of America National Submission to the United Nations Secretary General Pursuant to UN General Assembly Resolution 75/36," 2021, 36, https://front.un-arm.org/wp-content/uploads/2021/05/04292021-US-National-Submission-for-UNGA-Resolution-75.36.pdf.
[50] "United States Space Priorities Framework" (The White House, December 2021), https://www.whitehouse.gov/wp-content/uploads/2021/12/United-States-Space-Priorities-Framework-_-December-1-2021.pdf.

debris removal" from the lower earth orbit zone.[51] The US-led policy approach of SPD-3 is consistent with the recommendations we will propose in this report.

US Department of Transportation (DOT): FAA

Under the US Department of Transportation is the Federal Aviation Administration and within that is the Office of Commercial Space Transportation. The Federal Aviation Administration (FAA) came about in 1958, and it is a regulatory body over civil aviation.[52] The Office of Commercial Space Transportation (AST) was established in 1984 and is focused on regulating US commercial space launches and reentries, ensuring those activities comply with US international space law and recommending appropriate changes to statutes, treaties, policies, plans, regulations, and procedures.[53]

Orbital Debris Response: Title 14 of the Code of Federal Regulations (CFR)

The FAA developed orbital debris-related regulations for the US launch industry using Title 14 of the Code of Federal Regulations.[54] Recently, it has stated that it plans to model its regulations with the *USG Orbital Debris Mitigation Standard Practices*, to be under a separate rule to be finalized in the coming years.[55]

[51] "Space Policy Directive-3, National Space Traffic Management Policy" (The White House), accessed May 18, 2022, https://trumpwhitehouse.archives.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/.
[52] "Mission | Federal Aviation Administration," accessed May 9, 2022, https://www.faa.gov/about/mission.
[53] "About the Office of Commercial Space Transportation | Federal Aviation Administration," accessed May 9, 2022, https://www.faa.gov/about/office_org/headquarters_offices/ast.
[54] "Second Quarter 2002 Quarterly Launch Report" (FAA, 2002), https://www.faa.gov/about/office_org/headquarters_offices/ast/media/quarter0202.pdf.
[55] Heather Krause, "FAA Continues to Update Regulations and Faces Challenges to Overseeing an Evolving Industry" (United States Government Accountability Office), accessed May 9, 2022, https://www.gao.gov/assets/gao-21-105268.pdf.

Federal Communications Commission (FCC)

There is also the Federal Communications Commission (FCC), an independent agency founded in 1934, that regulates non-governmental electronic communications across the United States and in space.[56]

Orbital Debris Response: Update of Title 47 of the Code of Federal Regulations (CFR)

The FCC updated its *Orbital Debris in the New Space Age, Report and Order and Further Notice of Proposed Rulemaking* in Title 47 of the Code of Federal Regulations and released it on April 24, 2020.[57]

National Space Council (NSpC)

At the White House sits the National Space Council (NSpC) established in 1989 with the signing of the National Aeronautics and Space Administration Authorization Act. Non-operational from 1993 to 2017, the return of the NSpC is the synchronization of the United States' civil, commercial, and national security space activities.[58] There are two things of note. First, this council's primary duty is to advise and assist the President in space policy development and implementation. While the council consists of persons from the Executive Office of the President, the Users Advisory Group, and a Federal Advisory Committee made up of experts within the industry, academia, and other non-Federal organizations, its council and actions are directed solely toward the President. This leaves other agencies, offices, and regulatory bodies without a coordinated response of US Space policy. Second, as mentioned,

[56] "What We Do," Federal Communications Commission, November 22, 2010, https://www.fcc.gov/about-fcc/what-we-do.
[57] "FCC Updates Orbital Debris Mitigation Rules for the New Space Age," Federal Communications Commission, April 24, 2020, https://www.fcc.gov/document/fcc-updates-orbital-debris-mitigation-rules-new-space-age-0.
[58] "National Space Council," The White House, accessed April 7, 2022, https://www.whitehouse.gov/spacecouncil/.

this entity's existence is vulnerable in transitions of Presidential power. Therefore, even if the council can become an advisory council to all US space operators, we cannot guarantee that a coordinated response will be available despite the administration.

Orbital Debris Response: Diplomatic Reports

While leaders of the National Space Council, Scott Pace (Executive Secretary 2017-2020) and Vice President Kamala Harris (current Chair) have given diplomatic statements about "having a long dialogue" with US agencies about orbital debris mitigation regulations[59] and condemning the use of ASATs, there have been no reports or documents released by NSpC about orbital debris. However, a report has been released by the Orbital Debris Research and Development Interagency Working Group (ODRAD IWG)[60] with plans to release another report in 2022.[61] Under the guidance of the ODRAD IWG, the White House released its 2021 *United States Space Priorities Framework* that states the US will, "maintain a robust and responsible US space enterprise," and, "preserve space for current and future generations," through mitigation, tracking, and remediation of orbital debris.[62]

[59] "National Space Council in Discussions on FCC Orbital Debris Policies - SpaceNews," accessed May 9, 2022, https://spacenews.com/national-space-council-in-discussions-on-fcc-orbital-debris-policies/.
[60] Orbital Debris Research and Development Interagency Working Group, "2021 National Orbital Debris Research and Development Plan" (Office of Science and Technology Policy, n.d.), https://trumpwhitehouse.archives.gov/wp-content/uploads/2021/01/National-Orbital-Debris-RD-Plan-2021.pdf.
[61] "Orbital Debris Research and Development Interagency Working Group Listening Sessions," Federal Register, December 17, 2021, https://www.federalregister.gov/documents/2021/12/17/2021-27331/orbital-debris-research-and-development-interagency-working-group-listening-sessions.
[62] "United States Space Priorities Framework."

The Private Sector

The US government has stated that it wants to support private companies in developing orbital debris removal technologies. In 2021, the Trump administration encouraged private companies to develop orbital debris removal technologies and proposed that data from commercial companies be integrated into an open-architecture database.[63] Space Force is currently investing in a project called Orbital Prime, which will revitalize the on-orbit repair, assembly, and manufacturing (OSAM) market using active debris removal (ADR) as a use case for the underlying technology. This program will fund commercially developed technologies to develop and conduct OSAM technology and services.

The current issue is that the US government's support for most private companies is still at the verbal stage, and there is no widespread technical support or investment in them. So far, some companies have proposed clear experimental plans and are still in the financing stage, and they are still waiting for investment.

Given the US's desire to be the leader in orbital debris mitigation, we need to solve more problems within a shorter period of time. The DoD spends less than $1 billion a year directly on the management of orbital debris and has not made any significant investments in the development of ADR technology. This is far from enough. Fortunately, there has not yet been a national effort to develop a company related to orbital debris mitigation by any other countries.

[63] Orbital Debris Research and Development Interagency Working Group, "2021 National Orbital Debris Research and Development Plan."

Currently, US domestic government and capital markets are far from investing in companies related to orbital debris removal, nor has NASA committed support for such technologies. This has resulted in US-based private companies like OrbitGuardians and Raytheon BBN not being as mature as Japan's Astroscale, which was developed with the assistance of their national government. Yet, there is now an opportunity for other forms of technology and companies to be a part of the US's approach to orbital debris.

LeoLabs

LeoLabs is the world's first and only provider of commercial radar tracking services for objects in low Earth orbit. They offer the richest automatic data, the greatest debris detail and resolution, and the most responsive ephemeris generation.[64]

The Space Data Association (SDA)

The Space Data Association (SDA) is an international organization that brings together satellite operators to support the controlled, reliable, and efficient sharing of data critical to the safety and integrity of the space environment. SDA's membership includes the world's leading satellite communications companies.[65]

[64] "LeoLabs | The Mapping Platform for Space," LeoLabs, accessed May 23, 2022, https://leolabs.space/.
[65] "Welcome to the Space Data Association," Space Data Association, accessed May 23, 2022, https://www.space-data.org/sda/.

The Education Sector

FFRDCs

Since the Second World War, Federally Funded Research and Development Centers (FFRDCs) have been an instrumental part of US technological and economic leadership, both in technology and policy. FFRDCs are hybrid ventures with private sector resources which act under a public directive. Considered the third leg of a "three-legged stool," FFRDCs mesh the objectivity of the federal government with the specialization of the private sector. Effectively, a highly specialized research department with access to US government data, without the complications of commercial or monetary interests.

In the context of space issues, one of the best-known FFRDCs is the Jet Propulsion Laboratory (JPL), a group initially founded in the 1930s by a professor at the California Institute of Technology under GALCIT. Under US Army Air Corps sponsorship since 1936, it adopted the JPL name in 1943 after analyzing the Jet-propelled V-2 missiles that Germany was sending into England. While formal records track the first FFRDC as the RAND Corporation founded in 1947 and the NASA/JPL relationship beginning in 1958, the 20-year relationship between JPL and the US Army set precedence on how valuable these relationships were. Partnering with NASA, JPL grew alongside the US space program and provides a variety of technical advice on communication and tracking issues for space vehicles. The JPL website illustrates its longstanding ties to NASA with topics that include reports on satellites that observe the Earth or outer space.[66]

[66] "NASA Jet Propulsion Laboratory," NASA Jet Propulsion Laboratory, accessed May 23, 2022, https://www.jpl.nasa.gov/.

Another significant FFRDC is The Aerospace Corporation, founded in 1960. Aerospace has played an important role in US manned space programs and views its role as supporting "government customers with continuous engagement and unique perspective that spans across a broad range of mission areas".[67] In a recent (March 2022) article, Michael Gleason, a national security senior project engineer at Aerospace, published a paper expressing the need for international standards of behavior for safe space governance. He noted; "Abiding by norms of behavior constrains freedom of action which states may be unwilling to do unless they are reasonably assured that other states exercise the same level of restraint in space".[68] Gleason argues that the best basis for such assurance is the sharing of international space situational awareness data.

Numerous FFRDCs have worked on projects relating to STM and SSM. However, JPL is the only FFRDC with a direct association to NASA, where it acts under a research and development laboratory activity type. While there has been significant progress made through DOD-associated FFRDCs on related national security projects, there is no existing program primarily focused on space debris, with the topic additionally not under the mission directive of existing space-related FFRDCs like JPL.

University of Washington

The University of Washington is taking enormous strides in providing integrated data and space-related education. Housed at UW is the Space Law, Data and Policy Program

[67] "Advancing Collaboration Across a Rapidly Evolving Space Enterprise | The Aerospace Corporation," Aerospace Corporation, accessed May 18, 2022, https://aerospace.org/article/advancing-collaboration-across-rapidly-evolving-space-enterprise.
[68] Micheal Gleason, "No Haven For Misbehavin': A Framework For Verifying Space Norms" (Aerospace Corporation, March 2022), https://csps.aerospace.org/sites/default/files/2022-03/Gleason_VerifyingSpaceNorms_20220317.pdf.

(SLDP)[69]which is the world's first cross-sector institute focusing on the intersection of space law, data, and policy. The program's core interests include space traffic management, maritime domain awareness, and commercial human spaceflight. Additionally, the program has hosted over 35 space dialogues in partnership with other space-affiliated organizations to allow students to hear from leading experts on space from all disciplines.[70] This program helps train future generations to find innovative solutions to problems like orbital debris. Also at UW is the Paul G. Allen School of Computer Science and Engineering, known as one of the nation's most renowned schools with disciplines that include data science, data management, and visualization. The Paul G. Allen school has also played an integral role in the establishment of the University of Washington eScience Institute. The eScience Institute comprises a diverse group of individuals with backgrounds in physics, astronomy, bioengineering, bioinformatics, data management techniques, and computer science. They answer fundamental questions through the use of large and complex data. The eScience Institute is a hub for data-intensive discovery, working on the best practices of data science and the domain sciences (including space science) that benefit from them.[71] UW also has the Information School, or iSchool, with academics focused on information management. Information management at UW draws from multiple fields and is concerned with systems used to collect, manage, preserve, store, and deliver information and organizational and social contexts in which information exists.[72]

[69] "Space Law, Data and Policy," UW School of Law, accessed May 19, 2022, https://www.law.uw.edu/academics/programs/global-business-law-institute/sldp/.
[70] "2021-2022 UW Space Dialogues," SPARC, accessed May 22, 2022, https://www.sparc.uw.edu/events/.
[71] Bill Howe, "About Us," eScience Institute, accessed May 24, 2022, https://escience.washington.edu/about-us/.
[72] "Information Management Master's," UW Information School, accessed May 24, 2022, https://ischool.uw.edu/programs/msim.

University of Texas Austin

The University of Texas Austin offers another unique interdisciplinary education to students through their Space Security, Safety, and Sustainability program.[73] This program provides a transdisciplinary approach to space with classes on security, technology, and policy. Rather than teaching students a single discipline, it prepares students to face the vast amount of cooperation, innovation, and regulation that goes into space. The United States Space Force recognized this and recently signed a Memorandum of Understanding (MOU) to utilize the resources of UTA to train future space guardians.[74] This partnership comes as no surprise due to the extensive history UTA has in partnering with NASA, the US Air Force, and Defense contractors. Additionally, UTA is one of the leading educational institutes on space debris and hosts one of the world's most powerful supercomputers. These resources are helping the US lead in addressing some of the most pressing issues.

[73] "Space Security, Safety, and Sustainability," The Strauss Center, accessed May 19, 2022, https://www.strausscenter.org/space-security-safety-and-sustainability/.
[74] Daniel Oberhaus, "Space Force Enlists UT Austin to Help with Cutting-Edge Research," *The Alcalde* (blog), January 1, 2022, https://alcalde.texasexes.org/2022/01/space-force-enlists-ut-austin-to-help-with-cutting-edge-research/.

Reflection

While there have been individual responses to orbital debris from multiple US entities, there has not yet been a response that would utilize integrated systems of operation and provide greater clarity and accessibility to international partners. There is, in fact, an overlap between some orbital debris responses. However, the response of one sector may not fit all of the needs of another. For example, the FCC's *Orbital Debris Mitigation Rules for the New Space Age* sparked controversy in the commercial sector as many said the rules lack technological competency. Additionally, the diplomatic responses from the National Space Council may cater to our international partners and allies and some agencies adhering to guidance. However, they do not align with the FCC[75] or the Department of Defense[76] ambitions for tighter regulations. Thus, the US needs a unified federal response to the multifaceted threat of the accumulation of orbital debris. This issue cannot be resolved with one single action; rather it requires the synchronization of public, private, and educational sectors.

[75] "FCC Updates Orbital Debris Mitigation Rules for the New Space Age."
[76] Sandra Erwin, "U.S. to Support International Effort to Set Rules of Behavior in Space," SpaceNews, February 24, 2021, https://spacenews.com/u-s-to-support-international-effort-to-set-rules-of-behavior-in-space/."

Expanding and Transforming ODRAD IWG

The Orbital Debris Research and Development Interagency Working Group (ODRAD IWG) is a working group under the subcommittee for Space Weather, Security, and Hazards, within the Committee on Homeland and National Security in the National Science and Technology Council. ODRAD IWG, "seeks to coordinate the activities of Executive departments and agencies to promote the sustainability of the space environment, as well as space domain safety and security, through coordinated research and development (R&D) activities to overcome scientific and technical challenges associated with orbital debris risk management," as stated in the 2021 National Orbital Debris Research and Development Plan from the Executive Office of the President of the United States[77] and plans to release another in 2022. Successive administrations have recognized this working group as a necessity for US space activity. Henceforth we wish to expand and transform the commendable work of ODRAD IWG so that its work can continue to grow and contribute to US space activity in the long term.

Expansion

The working group does excellent and necessary work in attempting to develop a government-wide orbital debris implementation plan, examining R&D activities as well as other considerations such as policy levers, international engagements, and other ideas outside of R&D solutions that may help build a cohesive implementation strategy. It is currently hosting virtual listening sessions to hear from members of the public about ideas, problems, and solutions regarding the accumulation of orbital debris. There are two virtual listening sessions,

[77] Orbital Debris Research and Development Interagency Working Group, "2021 National Orbital Debris Research and Development Plan."

one addressing debris mitigation and the other addressing debris remediation. This collection of quantitative and qualitative data needs analysis and implementation in a body that can regulate space-faring activity based on this data. ODRAD IWG recognizes the need for this next step in their attempt to develop an implementation plan.

Transformation

ODRAD IWG currently stands as a working group, which typically is organized for their work to be done over a short duration of time. Orbital debris in Earth's orbit at altitudes of 800 km is measured to decay only after several centuries, and orbital debris at altitudes of 1,000 km is measured to exist for a thousand years or more.[78] To ensure that the work ODRAD IWG is kept through the long-term duration of tackling orbital debris, we advise that the working group be formalized instead as a committee. This committee could also serve the conversation of orbital debris as we begin to venture onto other celestial bodies. Our proposal for the committee needed can be found in the following section.

[78] "ARES | Orbital Debris Program Office | Frequently Asked Questions," accessed May 18, 2022, https://orbitaldebris.jsc.nasa.gov/faq/.

Policy Recommendation

Preface

The following policy recommendation is being made to the space-related regulatory body, the Federal Communications Commission, the space-related Federal Executive Departments, and the National Space Council based on the sources and analysis in this report. While we propose one primary recommendation, it is essential to note that our solution contains several functions that may be individually enacted. However, our solution will be most effective and sustainable if these functions are implemented synchronously.

CODA

We are proposing the Committee on Orbital Debris Affairs (CODA), an interagency committee within the Federal Communications Commission (FCC) that will function as an Advisory Committee established under the Federal Advisory Committee Act (FACA). CODA is an institutionalized and sustained solution to the problem of an uncoordinated federal response to the critical accumulation of orbital debris. CODA will build upon the work of the Orbital Research and Development Interagency Working Group by going beyond the collection of information and organizing the collected quantitative and qualitative data to develop regulatory policy recommendations that will be made to a space-related regulatory body. There will be three primary elements that we suggest CODA act on:

- Establishing an additional FFRDC in partnership with NASA with objectives to lead in the development of space debris mitigation disciplines, institute data organization programs, and recommend rules, regulations, and definitions to protect US assets in space.
- Championing domestic entities to specialize in orbital debris data collection through a federal partnership to solidify and promote US leadership as a hub for the commercial space industry.
- Leading a multinational collaboration with objectives to continue expanding and updating USSPACECOM's Space Situational/Domain Awareness (SSA/SDA) program, help transition its operational control to the Department of Commerce, and use it as a platform to share definitions, standards, and norms.

These elements will not be implemented in the abstract, but rather in a 3-tier system that CODA oversees. This will organize and focus the pre-existing orbital debris responses from current institutions.

The Committee on Orbital Debris Affairs (CODA) will be an integrated system composed of three primary tiers: Tier 1: Data Collection, Tier 2: Data Organization, and Tier 3: Regulatory Policy Recommendation to the Federal Communications Commission, for the long-term existence of orbital debris.

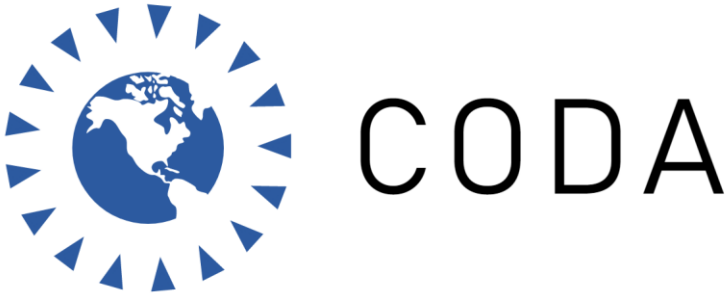

Figure 6 - [Committee on Orbital Debris Affairs Logo]

We recommend that the United States form the Committee on Orbital Debris Affairs (acronym CODA) within the Federal Communications Commission as an interagency committee that organizes pre-existing institutions through data collection, data analysis, and regulatory policy recommendations for the FCC to better address the multifaceted issue of orbital debris containment and mitigation.

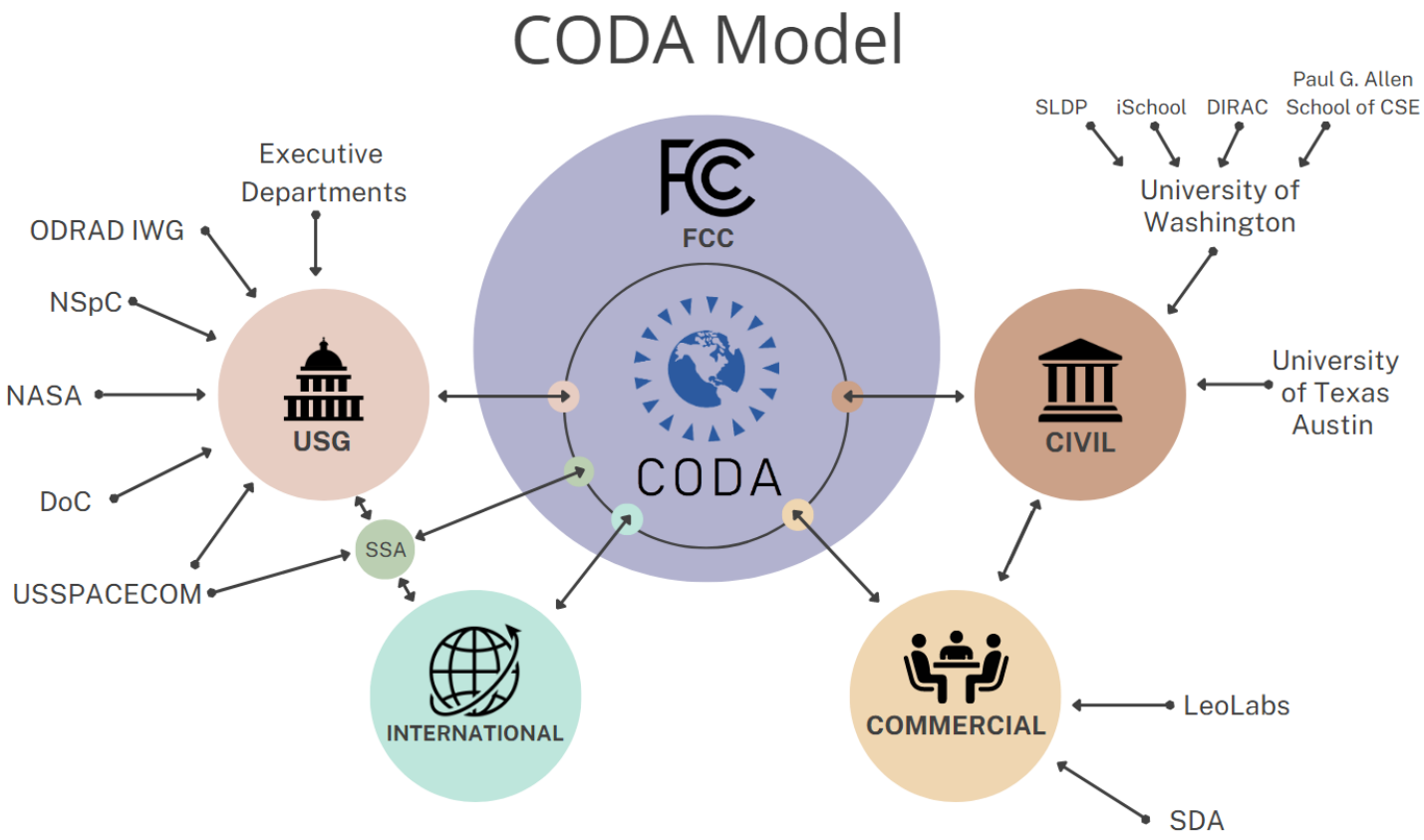

Figure 7 - [CODA System Model]

Operations Involving CODA

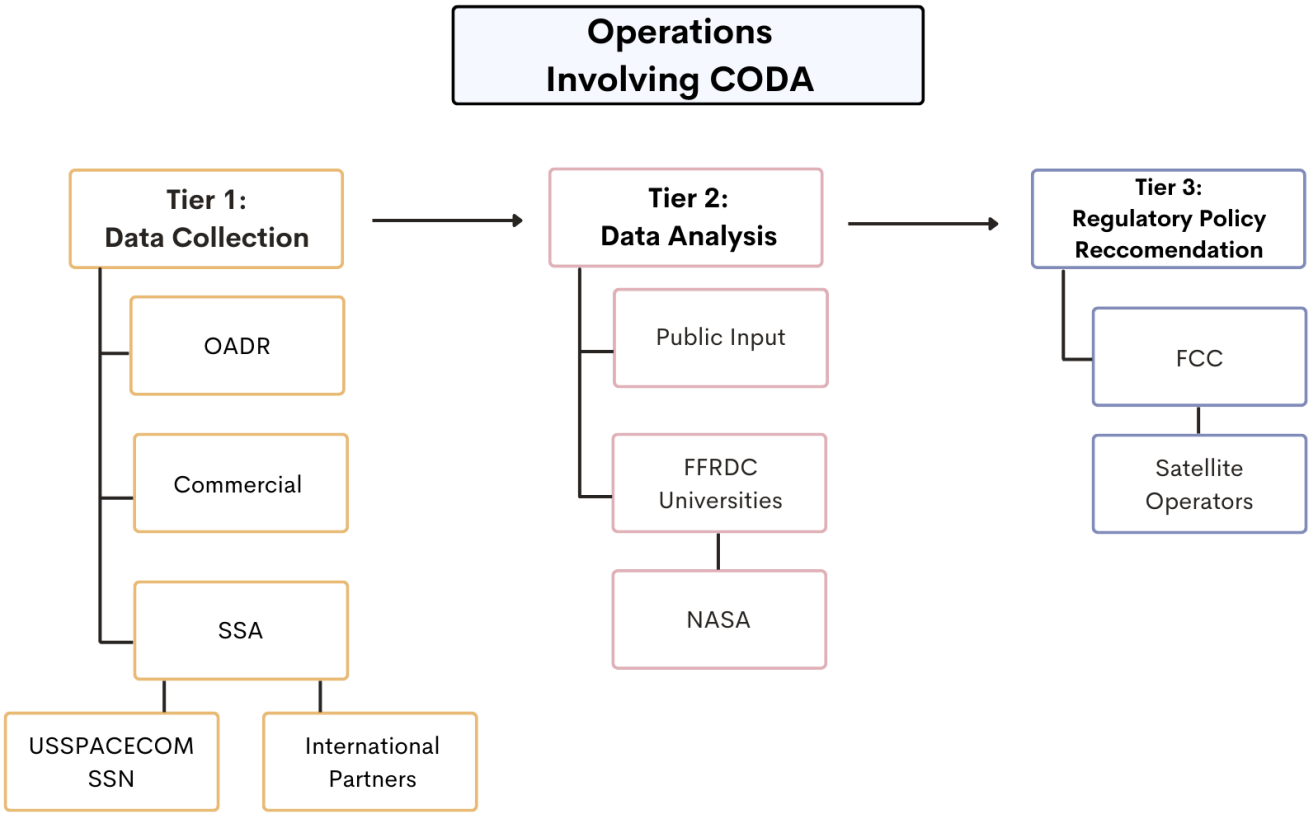

Figure 8 - [Operations Involving CODA Model]

Tier 1: Data Collection – Sourcing from SSA and Space Data Focused Companies

In Tier 1, CODA will collect quantitative data from federal and commercial bodies and qualitative data from civil and international.

SSA as a Means Towards Integration

CODA will help transition operational control of the USSPACECOM's SSA program over to NOAA's Office of Space Commerce. The data analysts and operators from the current 18th Space Defense Squadron will be inherited by NOAA to help run this newly expanded SSA

program and lead in integration with the existing SSA frameworks within the DoC. The SSN will remain under USSPACECOM control and will send data deemed non-confidential or emergency to the SSA program within NOAA to handle and distribute using its burgeoning OADR system.[79] CODA should also be authorized by Congress to seek out and sign data-sharing agreements in place of NOAA, something that USSPACECOM currently manages.

As OADR and STM within the DoC are being developed, CODA should continue the work of expanding upon SSA data-sharing agreements with countries, private companies, and public institutions. This will help unify the international community in terms of data standards, working to unify the disparate ways that satellite data is managed. As more data-sharing agreements are signed, more parties will become familiar with how the US operates its SSA, especially regarding data types, data collection, and database management. By working more closely with international space agencies, the US can encourage them to join CCSDS, further expanding the reach of the standardization that the US has worked to create in the first place. Increased standardized practices among international space actors will create a better environment for creating an effective space traffic management system in the future.[80]

SSA expansion will allow more parties to understand and become integrated within a system led by the USG. Expansion of the US's reach and influence upon satellite data should not stall while a new system is created. Creating more agreements now will mean the future DoC

[79] "Paving an Integrated Approach for Space's Traffic Jam Problem | The Aerospace Corporation," Aerospace Corporation, accessed May 23, 2022, https://aerospace.org/article/paving-integrated-approach-spaces-traffic-jam-problem.
[80] P. J. Blount, "Space Traffic Management: Standardizing On-Orbit Behavior," *American Journal of International Law* 113 (ed 2019): 120–24, https://doi.org/10.1017/aju.2019.17.

system will have more data to work with and more parties familiar and experienced with the USG-led system.

In addition, given that USSPACECOM SSN has very little coverage in Asia, Africa, and South America, CODA should work to sign data-sharing agreements with actors in those regions. The US can then cover a critical weakness within its current system. From here, the US should help build on SSA capabilities of these other nations to begin data collection from these countries. Data sharing goes both ways, with the US benefiting from more investment in these regions. Under our proposal, CODA would continue to play a leading role, promoting collaboration over competition where reliable international partnerships can be achieved.

Expansion of US-Led SSA

The US should sign Sharing Agreements with Ethiopia and Taiwan: countries that represent regions sorely missing from USSPACECOM's current list of partner nations. Ethiopia is relatively new to space affairs but is posed to accelerate participation in space activities in the near future, having just launched its first satellite in 2019.[81] Taiwan also has a fledgling space program and has recently invested in launching radar satellites to use for monitoring purposes.[82] US support through data sharing can help these countries more quickly develop their SSA capabilities and ensure the safety of their satellite networks using the US's vast amount of satellite and debris data. Increased investment and activity will also help grow other portions of those nations' government and commercial space sectors. Once those programs are

[81] "2020 in Review - Ethiopian Space Program," *Space in Africa* (blog), December 31, 2020, https://africanews.space/2020-in-review-ethiopian-space-program/.
[82] Asia Times Staff, "Taiwan to Launch Satellites, Land One on the Moon," Asia Times, February 14, 2019, https://asiatimes.com/2019/02/taiwan-to-launch-satellites-land-one-on-the-moon/.

up and running, they can provide much-needed data from regions that the US does not currently have data inflows from through its SSN.

Countries in key areas that have already signed agreements should be provided further support in the development of their SSA systems. Japan is one such country that has the capacity to manage a sophisticated SSA program that would provide essential data to the SSN. It currently has not yet constructed the necessary infrastructure to conduct debris and satellite monitoring.[83] Brazil is another such example, having signed an agreement in 2018. Brazil, and as a result the US, would benefit significantly from investment in radar infrastructure.

USSPACECOM needs to continue steady progress on upgrading systems to accommodate OMM to ensure compliance with the CCSDS standards. TLE should eventually be phased out into the SSA's internal data system to incorporate and share data more easily to and from outside sources. The conversion to OMM needs to be finished before transferring SSA responsibilities to the DoC to allow for a smooth transition.

Utilizing Companies to Capture Satellite and Orbital Debris Data

The collection and pooling of data is necessary for private companies and governments to facilitate efficient collaboration. LeoLabs is a private company that tracks orbital objects and debris through a network of radars, including an archive of radar deviations and residuals, state vector covariances, scheduled radar maintenance windows, schedules for future measurements, and past measurement schedules. Each radar tracks thousands of objects per hour — they use phased-array technology to switch from one object to the next every

[83] "JAXA | Space Situational Awareness (SSA) System," JAXA | Japan Aerospace Exploration Agency, accessed May 10, 2022, https://global.jaxa.jp/projects/ssa/.

millisecond. For polling data, the Space Data Association collates independently pooled data from operators to prevent collisions. CODA can serve as a medium between private companies and institutions, collecting their data on satellites and orbital debris, helping them to integrate their data resources for sharing and greatly improve efficiency and transparency between commercial and public sectors.

Considering that private companies that collect data do so for profit, CODA can act as a credible and competent third party to safeguard their cooperation. These companies are now offering data-sharing services for a subscription fee. Therefore, NOAA's Office of Space Commerce under the Department of Commerce should pay them an acceptable annual subscription fee, one that is more than the regular fee a normal consumer would pay. This protects the company's profitability and data sharing while maintaining public accessibility.

Tier 2: Data Organization — Utilizing a University Through a NASA Partnered FFRDC

In Tier 2, CODA will organize data collected in Tier 1 to find the best mitigation techniques to recommend to the FCC. To do this, CODA must develop relationships with data scientists, public institutions, and companies. We recommend the best way to start is to implement a Federally Funded Research and Development Center (FFRDC), specifically in a university under NASA sponsorship. This will guarantee a sustainable institutional structure and flow of eager bright minds contributing and gaining training on space affairs. The USG Federal Acquisition Regulations on FFRDCs go to the core of this policy recommendation; as there is no current specialized entity, one must be created.[84] The April 2022 report by MITRE and NAPA details an extenuating need for Global Space Traffic Coordination (GSTC) as a "pressing issue" threatening orbital technology and earth-based security and economic concerns.[85] Beyond acknowledging a pending orbital crisis, MITRE and NAPA acknowledge the issue and opportunity that the lack of a GSTC/STM leadership poses. A NASA sponsored FFRDC fills the void of STM policy and data management, while answering the stated public and global need for sector leadership. The question then becomes where best to center this initiative based on industry leaders and potential effectiveness.

[84] "Master Government List of Federally Funded R&D Centers," National Science Foundation, February 2022, https://www.nsf.gov/statistics/ffrdclist/.
[85] Roger Kodat et al., "Advancing A Strategic Approach To Global Space Traffic Coordination" (MITRE Corporation, April 2022), https://www.mitre.org/sites/default/files/publications/pr-22-0790-advancing-a-strategic-approach-to-global-space-traffic-coordination.pdf.

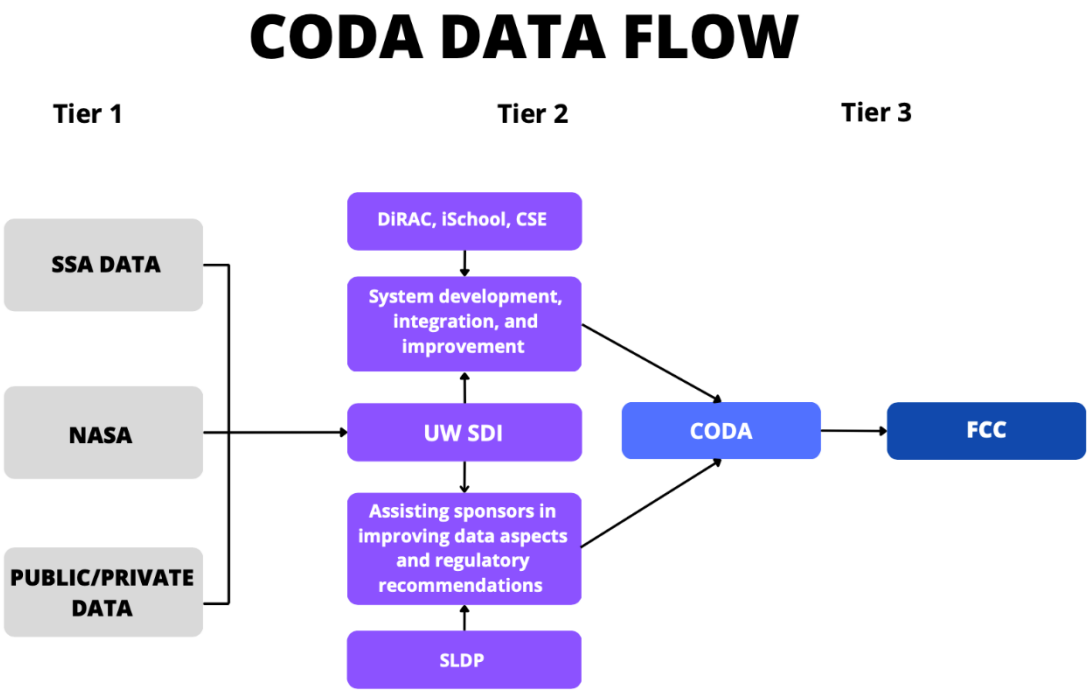

Figure 9 - [CODA Data Flow Chart]

Our recommendation consists of a new FFRDC at the University of Washington under NASA sponsorship, with an MOU signed with the FCC as the chair of CODA. This FFRDC would be called The University of Washington Space Data Institute (UW SDI). UW SDI will utilize the JPL organizational model under the systems engineering and integration (SEI) activity model as defined by the DoD and the National Science Foundation (NSF). Under the SEI activity model, UW SDI is centered around the "development & acquisition of system hardware and software" through the continuous improvement of systems operations and logistics as it pertains to SSA. It will have a distinct specialization in the organization of data collected in Tier 1 and the

development of orbital debris management technology, including identifying what types of data are most useful, developing new algorithms, working on data fusion, and improving existing architectures. The data the UW SDI will be utilizing will consist of commercial and public data on SSA that is within the OADR system that will be operational by 2024 under NOAA, as well as NASA's existing data on current objects in space.[86] Ultimately, UW SDI will serve as a data clearinghouse, utilizing and improving upon current algorithms for orbital tracking & SSA management, while maintaining a constant flow of information and regulatory recommendations to CODA.

We believe CODA will be best served through an FFRDC because they provide prompt and specialized solutions. This is especially true for orbital debris as there is no existing alternative source to satisfy the FFRDC's proposed mission. As technology and goals change in terms of STM, it will be important that CODA has a strong connection to current work being done on research, regulation, and innovation. With NASA's oversight, the FFRDC will not only have the resources to train future leaders in space but consistently improve how we are analyzing this data.

In the past, FFRDC allocation has centered around utilizing locales and pre-existing groups to meet a "specialized development need." Seattle is a prime location for a NASA sponsored FFRDC on orbital debris because of local data production and analysis capabilities. Five of the world's leading space industry and data companies (Boeing, Blue Origin, SpaceX, Amazon, and Microsoft) are either headquartered in or have significant investment in the state

[86] Marcia Smith, "NOAA's Space Data Repository Takes a Step Forward," February 11, 2022, https://spacepolicyonline.com/news/noaas-space-data-repository-takes-a-step-forward/.

economy. The utilization of these companies and their data "capital" is paramount to any effective initiative on SSA and STM, like the data partnerships between the FFRDC and federal sources.

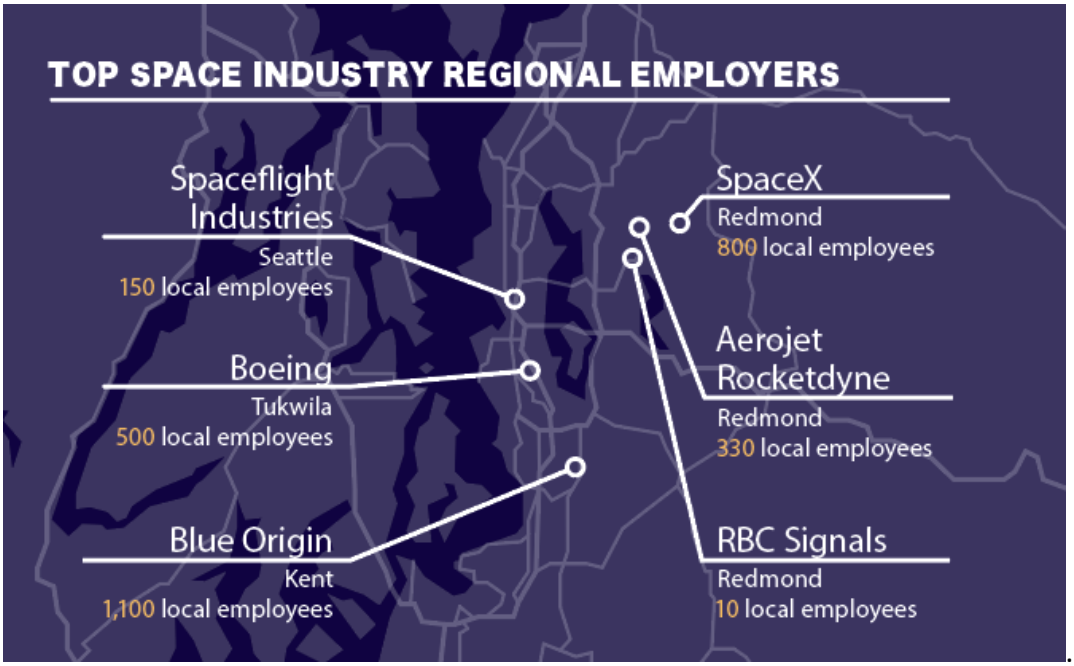

Figure 10 - [Map of Space Companies in Seattle][87]

University of Washington is the ideal place to institutionalize this FFRDC. As a leading university in computer science and informatics, UW mirrors the technological capability of Seattle to accurately manage and analyze relevant data. Through these programs, the university has already begun to pave the way toward educating students on the intersectionality of space as well as the important role data plays. Currently, UW houses the Institute of Data Intensive Research in Astrophysics and Cosmology (DiRAC), the Space Law, Data, and Policy program (SLDP), and the iSchool (informatics). We are proposing a sibling institute within the ischool (informatics) in partnership with DiRAC, SLDP, and the Paul G. Allen

[87] Todd Matthews, "Business of Space," 425Business, accessed May 20, 2022, https://www.425business.com/lifestyle/business-of-space/article_49ea8d3d-07da-5ff0-b947-dffa519e1fd3.html.

School of Computer Science and Engineering. UW SDI will fulfill its cross-discipline approach by focusing on organizing satellite and orbital debris data, as well as how to focus the data into policy for CODA to utilize. With NASA's oversight and resources, the FFRDC will have the capacity to consistently improve how we organize and utilize the data for STM.

To ensure that CODA receives the most up-to-date reports from the data collected and organized, we suggest an MOU be signed between the FCC and any relevant departments contributing to UW SDI. This will guarantee all reports are sent to CODA to give the most up-to-date information for any possible regulatory recommendation. A program at UW that will be critical in ensuring the data is organized into a policy focus will be the SLDP. SLDP is the world's first cross-sector institute focusing on the intersection of space law, data, and policy. SLDP offers unparalleled expertise in policy and regulatory recommendations, supported by a diverse range of faculty that are world-renowned in space affairs and data science, and which have already advocated for additional resources. Additionally, with companies like SpaceX, Boeing, Microsoft, and Amazon in the vicinity [Figure 10], the UW SDI FFRDC would be able to experiment with public and private partnerships as part of the educational training.

The University of Washington is missing a cohesive space debris mission that coordinates all ongoing programs and resources. Similar to the federal level, extensive and excellent work related to orbital debris and STM is occurring, yet these efforts must be focused on a specific goal to be efficient. In a congressional hearing on May 12th, 2022, public and private leaders in SSA called for policies and regulations on a federally organized strategy on space debris & STM. Included in the testimonies were concerns regarding the lack of funding to train students in scientific and policy SSA research, recognizing what capabilities are best served

commercially, and innovating new technological capabilities.[88] For CODA to understand how to address these challenging questions, we need an institution to organize and analyze our data to understand where we are and to focus on the next steps. Establishing an FFRDC would continue the long tradition of recognizing a void, a need, and an environment that can best bring targeted policy and technological advancements to fruition through government-university partnerships.

Hosting Public Events for Public Input

In line with the FCC, the ODRAD IWG, and the Office of Space Commerce, CODA would also host events to solicit input from the public, related sectors, international allies, and partners on the problem of orbital debris. This would serve as qualitative data that policy drafting members of CODA would take into consideration when recommending regulations for the FCC to implement. This will further strengthen the synchronization of the nation's national, commercial, and civil space activities.

Tier 3: Regulatory Policy Recommendation to the FCC

In Tier 3, the members of the committee will then examine the organized data and formulate regulatory policy recommendations to be given to the FCC for it to then decide on their implementation. These policy recommendations will be focused on how to best regulate US space actors from creating new orbital debris based on the data collected on the existing satellites and orbital debris.

[88] Marcia Smith, "As Space Gets More Crowded, House Committee Still Questioning SSA Path Forward," *Spacepolicyonline.Com* (blog), May 17, 2022, https://spacepolicyonline.com/news/as-space-gets-more-crowded-house-committee-still-questioning-ssa-path-forward/.

Implementation of CODA

Once CODA is implemented, it is integral that it is sustained. Otherwise, we find ourselves back at the same institutional problem we are currently facing. We plan to transform the ODRAD IWG and combine its current efforts with those planned for CODA. As a committee, CODA would exist long term and hold the potential to aid the White House in their 2021 priority of "Preserving Space for Current and Future Generations,"[89].

Where is CODA Located?

CODA will be an interagency committee within the Federal Communications Commission as an Advisory Committee established under the Federal Advisory Committee Act.[90] Primary activity of the committee will be conducted at the parental agency in Washington DC. However, activity of Tier 2 will be done at a university (e.g., the University of Washington) with the supervision of NASA.

Why the FCC?

The Federal Communications Commission has a taken a major stride in this direction with its update of the *Orbital Debris Mitigation Rules for the New Space Age* in Title 47 of the Code of Federal Regulations and major executive US bodies may have a strong probability of showing support for CODA to be within the FCC. The DoC already defers to the FCC for licensing requirements for orbital debris and spacecraft disposal. The DoD is looking for tighter regulations and has transferred space traffic management to the DoC. Considering CODA would

[89] "United States Space Priorities Framework."
[90] "Federal Advisory Committee Act Amendments," 5 U.S.C. app. § (1972), https://www.gsa.gov/cdnstatic/FACA-Statute-2013.pdf.

be both an aid to space traffic management and recommend regulations the DoD is looking for; it is likely the DoD will also support this recommendation. The FCC is an independent agency and already has a system of committees in place.[91] Therefore, CODA, as an advisory committee within the commission, will avoid the problem of becoming lost in an extensive bureaucracy. This concise streamline will make regulations made by the FCC more accessible to our international partners and allies. The FCC has stated in its report of the updates on *Orbital Debris Mitigation Rules for the New Space Age* that it has an interest in "avoiding duplicative requirements and standards".[92] Therefore, it is ill-advised to house CODA within another regulatory body when the FCC has already made substantial progress. Instead, we advise for the including these regulatory bodies over non-federal space operations as members of CODA for a coordinated rather than duplicative response.

[91] "Advisory Committees of the FCC," Federal Communications Commission, March 3, 2011, https://www.fcc.gov/about-fcc/advisory-committees-fcc.
[92] "FCC Updates Orbital Debris Mitigation Rules for the New Space Age."

CODA Members

The members of CODA are selected based on the need to continue the good work the Orbital Research and Development Interagency Working Group has already set forth. The members listed below are already current members of ODRAD IWG, and they are the principal bodies that have taken steps toward addressing the issue of orbital debris. Like ODRAD IWG, CODA wishes to bring their insightful efforts and expertise together.

Chair: Federal Communications Commission

Members

Department of Commerce
Department of Defense
Department of the Interior
Department of State
Department of Transportation
Federal Communications Commission
NASA Orbital Debris Program Office
National Space Council
Office of Management and Budget

Closing Statements

The time for change and national cooperation is now. The Committee on Orbital Debris Affairs (CODA) will serve as a body that collects, organizes, and disseminates data, and recommends policy to the FCC. Not only will the implementation of CODA sustainably advance the United States government's response to the problem of orbital debris, but with its links to civilian universities, CODA's operations will be institutionalized across academic and commercial platforms. With the integration of CODA, the United States will have the opportunity to pave the way toward a safer space. We will solidify our position as a global leader in innovation and space exploration while maintaining our national security. It is our formal request that CODA is considered as a viable and sustainable solution for the institutional change necessary to solve our orbital debris problem.

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