Examining the Failings of International and Domestic Policy to Address the Threat of Space Debris

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Abstract

As new satellites continue to be launched each year, orbital debris is becoming an ever growing threat. Especially in light of the rising popularity of mega-constellations, action needs to be taken in order to prevent the already congested near earth orbital environment from being filled with debris. To date, there have been no international laws to govern orbital debris mitigation, and domestic laws have failed to adequately address the issue. This paper uses *The Political Construction of Space Satellite Technology* by Henry Lambright as a conceptual framework to understand the controversies that have inhibited successful legislation in this area. Through this analysis, I have found that conflicting motivations of political actors have prevented the U.S. and international governing bodies from taking a more proactive approach to mitigating orbital debris.

Orbital Debris and The Political Construction of Technology

In October of 2022, the world will celebrate 65 years since the start of the Space Age, which commenced in 1957 with the launch of Sputnik-1 by the Soviet Union. Much has changed since this historic launch of the first man-made satellite to successfully enter Earth's orbit. The last 65 years have seen the launch of thousands of satellites from over 50 countries and the advent of the commercial space industry (Haroun et al., 2021). Developments in space technology have had a revolutionary impact on society. Satellites are critical to the way that we communicate, they provide vital data in monitoring climate change, and so much more; however, not without consequences. The rapidly increasing number of satellites in orbit has led to

concerns over the impact that orbital debris will have on the future of space exploration. Orbital debris is human-made objects that no longer serve a useful function but are still in orbit around Earth. Currently, the Department of Defense is tracking more that 27,000 known pieces of space debris. Much more debris - too small to be tracked but large enough to pose risks to future space missions - likely exists in the near earth environment. These pieces of debris, which are traveling at speeds up to 17,500 mph, can have detrimental effects on future space missions (NASA, 2021). Despite the mounting concern over orbital pollution little is being done to remove debris and prevent future pollution. There is currently no legal framework in place to prevent the continued pollution of the orbital environment, only non-binding orbital debris mitigation guidelines which individual countries can choose to implement (Haroun et al., 2021). In the U.S. there are several regulations governing commercial and government satellites, however, compliance with these rules remains low as a result of lax oversight by government agencies. Using the political construction of technology framework this paper aims to examine the way that coalition building and rhetoric have been used to hinder the development of more proactive orbital debris mitigation strategies. Current policy to mitigate space debris fails to adequately address the issue because the international guidelines focus on the impact to individuals and do not treat the protection of the space environment as a broader environmental issue.

Space law dealing with damage caused by collisions with orbital debris has been successful thus far because incidents have been very infrequent and thus can be dealt with on a case by case basis. As the quantity of debris left in orbit increases the rate of incidents related to space junk will increase and current regulations will be insufficient to address these issues. Additionally, while significant consideration has been given to preventing orbital debris from

interfering with space operations and causing property damage, very little attention is paid to the inherent value of the environment of space. In *The Political Construction of Space Satellite Technology*, Lambright (1994) explores the interplay between administrative and political actors and the technical community during the development of three different large-scale satellite technologies. According to Lambright, “the literature on social construction of technology and actor-network theory suggests that assembling "coalitions" of support and conveying a certain "rhetoric" of technology are important to moving technology forward” (pg.1). He uses the concepts of coalition building and rhetoric to explain how government agencies attempt to become the obligatory point of passage for technical and political considerations during the development of new technologies. They do this in order to control the external environment and provide stability for scientists and engineers in order to promote the success of new technologies (Lambright, 1994). What happens when the effort to provide stability and encourage technological advancement comes in conflict with ethical concerns related to the technology? In my paper, I will be answering this question by looking at how political and commercial actors involved in orbital debris mitigation policy have attempted to appeal to the public interest and use coalition building strategies in order to avoid adopting a more proactive, and restrictive, approach to debris mitigation.

I will begin by establishing the significance of the problem through evaluating the potential risk posed by orbital debris. Next, I will discuss the international and domestic policy background, and conflicts that have arisen in recent years. Finally, I will explore the way that commercial actors have exerted influence on the rulemaking process. The focus of this paper will be mainly on U.S. policy, however, due to the influential role that the U.S. plays in setting

international orbital debris mitigation guidelines, examining U.S. policy provides a comprehensive overview of the issue.

Rising Threat of Collisions

One of the biggest threats of orbital pollution is the risk of collisions with other satellites in orbit. There have been several documented cases of collisions between satellites and orbital debris. In 2021, the U.S. Space Force linked the destruction of a Chinese military satellite, Yunhain-1 (02), to a piece of debris from the Russian Cosmos 2333 military signals intelligence satellite launched in 1996 (Jones, 2022). Prior to this incident the last recorded incident of a satellite colliding with, and being destroyed by orbital debris was the 2009 collision between Iridium 33 and the Russian satellite, Cosmo 2251 (Johnson, 2009). Fortunately collisions of this kind are currently extremely rare, however, as major companies continue to place satellites into orbit at an unprecedented rate, the frequency of collisions is likely to increase. SpaceX alone plans to add tens of thousands of new satellites in the next few years as it builds its Starlink mega-constellation. Other companies like Amazon, OneWeb, GW, and Telesat have similar plans to create vast networks of satellites to provide high speed internet access (Boley and Byers, 2021). The vast number of satellites being launched by omega-constellation operators could quickly result in an overcrowding of the orbital environment.

Kessler Effect and the Threat of Mega-Constellations

In 1978, NASA scientist Donald Kessler, proposed what is now known as “Kessler syndrome” or the cascade effect, a hypothesis for the worst-case scenario outcome of rising orbital pollution which would leave humanity stranded on earth. Kessler proposes that “As the

number of artificial satellites in earth orbit increases, the probability of collisions between satellites also increases. Satellite collisions would produce orbiting fragments, each of which would increase the probability of further collisions, leading to the growth of a belt of debris around the earth" (p.1). Essentially, in this scenario each collision would create new pieces of debris that would go on to cause additional collisions, resulting in an exponential growth of the quantity of debris in LEO. Eventually, if the amount of debris in orbit became great enough it would be impossible to launch any new spacecraft into orbit and humanity would be cut off from access to space. While innovations in spacecraft technology, like improved maneuverability, have greatly delayed the risk of Kessler syndrome, it is still a very real threat especially as mega-constellations become ubiquitous. A study by the European Space Agency (ESA) Space Debris Office found that mega-constellations could have a substantial impact on the collision risk in LEO, especially for orbits with lower altitudes (Parejo et al, 2021). SpaceX has plans to actively de-orbit its satellites at the end of their 5-6 year lifespan. While this method will prevent old satellites from becoming debris, it means that roughly 10 percent of satellites will be de-orbiting at a given time. These satellites have to pass through the congested LEO space, where the risk of catastrophic collisions is greatly enhanced.

International Policy Background

There is currently very little governance surrounding the Low Earth Orbit (LEO) environment and orbital debris. Orbital debris is not mentioned specifically in international law, however, the Outer Space Treaty (OST) of 1967, which serves as the foundation for all international space law, contains three articles with language relevant to this issue. These are article VI which expresses that "States party to this treaty shall bear international responsibility

for national activities in outer space" (OST, 1967), article VII which declares states liable for any damage caused by objects that they launch into space, and article IX which requires that states request a consultation if they have reason to believe that planned space activity could interfere with the activities of other states. The Liability Convention, which was adopted to clarify the intent of article VII of the OST, makes states liable for damage caused "caused elsewhere than on the surface of the Earth to a space object of one launching state or to persons or property on board such a space object of another launching state … only if the damage is due to its fault or the fault of persons for whom it is responsible" (Liability Convention, 1972). While this convention does not explicitly address orbital debris, it does provide some remedial framework for dealing with potential damage resulting from collision (National Research Council, 1995).

The main policy mechanism to actively prevent orbital pollution has, thus far, been the development of debris mitigation practices by the Inter-Agency Space Debris Coordination Committee (IADC). The foundation for these international guidelines was the U.S. Government Orbital Debris Mitigation Standard Practices (USG ODMSP), developed by NASA in 2001. Currently just over a dozen space agencies are members of the IADC. The debris mitigation guidelines proposed by the IADC have been adopted by the United Nation (UN) Committee for the Peaceful Uses of Outer Space (COPUOS). The guidelines are non binding, however, many major space faring nations have elected to enforce them as mandatory regulations within their own national policy (Larsen, 2018). Perhaps the most notable tenant of the IADC guidelines is the 25-year rules, which recommends that satellites in low Earth orbit do not remain in orbit for more than 25 years after their operational life span. Many nations enforce this guideline, however, compliance to the rule remains low. In 2021, the European Space Agency (ESA) published a report estimating that only about 15 to 25 percent of satellites in orbits that will not

naturally deorbit even attempt to comply with this rule (ESA, 2021). The reason for the low rate of compliance with these guidelines is complex. In this paper an Actor Network Theory analysis will be applied to this situation in order to determine why this policy has failed to protect the orbital environment from continued pollution.

One of the obvious challenges with the IADC guidelines is that they are voluntary and thus not enforceable on an international scale. The IADC intentionally opted to avoid the formal process of lawmaking in order to facilitate international cooperation and consensus. This consensus would have been unlikely if they had attempted a formal law making process, however, it means that the success of the IADC is dependent on its ability to withstand political forces and the assumption that participating nations uphold their agreement. Each member nation is responsible for their own adoption, monitoring, and enforcement; there is no legal recourse for states that choose not to comply. Additionally, while the nations that make up the IADC are all active members of COPUOS, the IADC itself is not a UN body and not an agency of COPUOS. As a result, the committee lacks geographic representation and does not have the authority to amend the guidelines as debris accumulation becomes a more pressing concern. The guidelines, which were approved by the UN General Assembly in 2008, were intended to be revised, however, no revisions have been made since their initial adoption (Larsen, 2018). While the existing guidelines provide a strong foundation for international cooperation, there is an increasing sense within the space community that these guidelines need to be strengthened in order to reflect new developments in space exploration. Most international space law was written at a time when space activities were almost exclusively conducted by government actors. Given the rise of the commercial space industry – which represents one of the greatest threats to

the orbital environment – significant changes must be made to the international legal regime and orbital debris mitigation practices.

US Standard Practices and Conflicting Perspectives

The USG ODMSP still defines the standard for orbital debris mitigation practices in the US. They apply to all US government organizations involved in space operations, and act as the foundation for requirements applying to commercial space activity licensed by the US. Additionally, since their initial conception in 2001, the US standard practices have been influential in international policy governing orbital debris. In 2018, President Trump released Space Policy Directive 3 (SPD-3), which recognized the urgency of managing orbital debris, and directed NASA to lead efforts to update the USG ODMSP. The updated USG ODMSP was published by NASA in December 2019, eighteen months following SPD-3, and included the introduction of operating practices for emerging space activities like small satellite and satellite constellation operation, rendezvous and proximity operations, and active debris removal. It also placed quantitative limits on the amount of debris that can be generated during normal operations of space vehicles, probability limits on collisions and explosions, and a reliability threshold on post operational lifetime disposal (Gleason, 2021).

Many stakeholders, including the director of the European Space Agency (ESA) and a growing number of commercial satellite operators, have questioned if the updated standard practices do enough to address new challenges facing the aerospace industry. In particular, the decision to maintain the long standing “25-year rule” has been the subject of significant criticism as some members of the space industry think the time frame is too long given the congestion of the LEO environment and the projected growth in the number of satellites. The decision drew

attention from the leaders of other major space agencies. In a press briefing Jan Woerner, the director of the ESA said that “We have to work on a shorter period” in light of the emergence of satellite mega-constellations (Foust, 2020).

During the interagency process of updating the standard practices several departments and federal agencies advocated for reducing the 25 year standard, however, they were met with strong opposition from NASA. The Chief Scientist for the NASA Orbital Debris Program, Dr. J.C. Liou, argued that the problem was arising from lack of adherence, not the guideline itself. Dr. Liou has publicly stated that NASA’s modeling did not show a significant reduction in the production of orbital debris with a tightening of the rule. According to the report, orbital debris is expected to grow by 330 percent over the next 200 years in a baseline scenario where no satellites comply with the rule. If compliance reaches 90 percent the projected growth in orbital debris falls to just 110 percent. The report also modeled a scenario with a five-year de-orbiting rule and 90 percent compliance and found that it reduces growth only slightly, to 100 percent (Foust, 2020). This report suggests that shortening the de-orbit period would have little impact on the growth of orbital debris, however, there are several significant limitations to NASA’s modeling. The model focuses solely on the growth in orbital debris over the next 200 years, and does not look at costs associated with detecting debris, predicting collision, and alerting satellite operators. Additionally, the model does not account for the massive constellations planned for deployment in the coming decade, which will contribute significantly to the creation of debris.

The result of inter-agency processes like this one often hinge on the interests of key agencies and their ability to form coalitions to promote these interests. In the case of the USG ODMSP there was a push from several agencies, including the DoD, the Federal Aviation Association (FAA), and the National Oceanic and Atmospheric Administration (NOAA), to set

stronger standards. NASA was the strongest opponent to tightening the 25 year rule, and also the agency tasked with leading the process. They are themselves a major satellite operator who would bear a significant portion of the cost of tightening the rule so they have a vested interest in keeping rules relaxed (Weeden, 2020).

The Role of the FCC in Tackling Space Junk

While the USG ODMSP sets the standard for government space operations, the licensure of commercial space operations mainly falls under the jurisdiction of the Federal Communications Commission (FCC). The FCC's current practice for assigning LEO orbital shells is on a first come first serve basis, allowing satellite companies like SpaceX to saturate the congested orbital environment with mega-constellations. The Space Act, which protects the commercial spaceflight industry from additional regulatory oversight until 2023, has left this practice in place (Runnels, 2022).

The FCC has its own set of orbital debris mitigation practices based on the USG ODMSP that private spacecraft companies are mandated to adhere to in order to be granted a license. In November 2018 the FCC issued its Notice of Proposed Rulemaking (NPRM) alerting the public to the intended changes to these regulations. During the comment period, which opened in early 2019, more than 80 comments were submitted by international agencies, industry representatives, and US agencies (Dodge, 2021). According to Michael P. Gleason (2021), a senior project engineer at the Center for Space Policy and Strategy, the ensuing "FCC rulemaking effort highlighted the natural tension that exists between the government's need for regulation to protect the safety, security, and sustainability of the space environment and industry's desire for minimal, clear, and consistent regulatory constraints" (p. 4). While many

key industry players recognize the importance of protecting the orbital environment for future generations, there is concern that increasing regulatory constraints could increase the cost of commercial space ventures and hinder the ability of US satellite companies to compete in the international market. In April of 2020 the FCC released a draft of its updated regulations. The draft included stringent requirements for satellite operators to compensate the government for any damage caused by their satellites. Under the rules projects applying for an FCC were to be bonded for up to $100 million, and satellites flying above 400 kilometers were required to have maneuverability allowing it to avoid collisions. The proposed rules were strongly opposed by members of congress and industry because they would put the U.S. aerospace industry at a disadvantage in the international market. Congress and Ultimately the FCC voted unanimously to remove these controversial rules from the update to the regulations (Gleason, 2021).

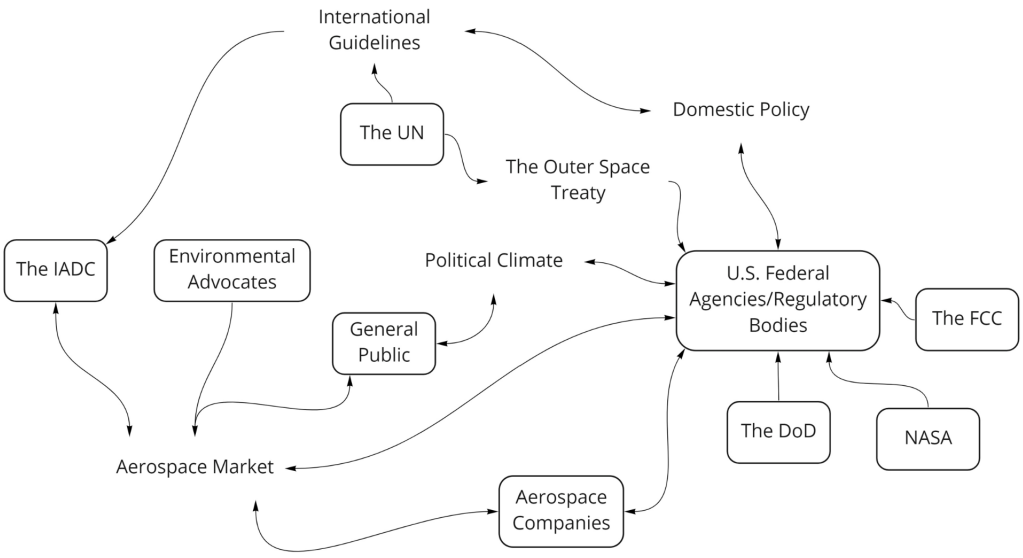

Figure 1: Mapping the Actors. Governmental and Commercial Actors Involved in the Orbital Debris Mitigation Policy Framework (Boyles, 2021)

Destabilization of the Rulemaking Process

There is near consensus within the scientific community that something must be done to address the growing threat of orbital debris as the number of satellites deployed into LEO continues to skyrocket, however, so far government agencies have failed to devise a proper regulator framework to address this issue. Examining the various political actors involved in domestic and international policy making is helpful for understanding why policy thus far has failed. One of the central shortcomings of the international legal regime governing space activities is that it was written at a time when space exploration was mainly limited to government actors. Since the OST was passed in 1967, the aerospace industry has become increasingly commercialized. SpaceX alone now owns 36 percent of all satellites in low earth orbit (Dewesoft, 2022). Domestic law, which was designed to implement these international obligations, provides little regulation on the space activities of companies like SpaceX.

The FCC has fallen under frequent criticism for the first come first serve approach to licensing and for showing favoritism towards SpaceX. They have routinely approved thousands of SpaceX satellites with minimal oversight and little consideration for environmental and collision risks despite the high rate of malfunction in their satellites. SpaceX has also been awarded millions of dollars in subsidies from the U.S. government to help them provide internet access to rural areas. In April, the FCC ruled that SpaceX could lower the altitude of future satellites in order to improve broadband speed (Goldstein, 2021). A decision which effectively gives SpaceX a monopoly over the lowest portion of earth's orbit. The power of commercial actors in the network has disincentivized regulatory bodies from passing stricter regulations to protect from orbital pollution. SpaceX has had great success using rhetoric to rebrand their

mega-constellation project as a force for social good by emphasizing the application of providing internet access to rural areas. This has allowed them to benefit from subsidies and lax oversight as well as exert sway over the regulatory process. Due to push back from groups like SpaceX and Boeing as well as the Department of Congress, the FCC has failed to form a coalition that would allow it to pass more stringent regulations.

Some promise has come in the form of the Space Safety Coalition (SSC), a group of companies, organizations, and other government and industry stakeholders which advocate for the safe use of outer space. The SSC has called for increased reliability in the de-orbit period for large constellations, and shorter end of life timelines. Many major satellite operators have joined the coalition, but SpaceX notably has not (Weeden, 2020). Through coalition building groups like the SSC hope to put pressure on international and domestic rulemakers to promote more proactive standard practices.

Conclusion

Orbital debris is a complex international issue with a wide network of intertwined actors each with their own motivations. Based on the continued adoption of new satellite technologies, and the growing quantity of debris in space, it is clear that space junk is an ever growing issue which must be dealt with on an international scale. Current policy to mitigate space debris fails to address the issue in a meaningful way because it prioritizes commercial and governmental interests and fails to treat orbital debris as the pressing environmental concern that it is. Using the political construction of technology framework to analyze developments in orbital debris mitigation practices reveals the way that strategies like coalition building and rhetoric have been used to hinder the development of more proactive approaches. The conflicting interest of various

government and commercial stakeholders has been a significant barrier to recent attempts to update legislation to address challenges posed by new developments in satellite technologies, like the rising popularity of mega-constellations. The FCC has adopted to push decisions about the 25-year rule and the regulation of satellite constellations to future rulemakings, however, these factors will most likely continue to hinder significant progress. In order to overcome these barriers there must be significant cooperation on a domestic and international level between government agencies and commercial actors. Groups like the SSC, which bring together commercial and government stakeholders, will be influential in promoting a better approach to orbital debris management.

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