A Wicked Evaluation of the Debris Crisis and the Militarization of Space

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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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STS RESEARCH PAPER

Introduction: Conflict and Pollution

In 1945 the first nuclear bomb was dropped, a war was won, and every war-fairing nation began an arms race to ensure a competitive advantage. Hundreds of nuclear tests would follow, contaminating test sites and the surrounding area with harsh poisons and radiation (Walsh, 2022). 70 years later these same nations have moved into the earth's orbit, but not with nuclear weapons or large explosives. Hundreds of military satellites with seemingly harmless capabilities such as surveillance, navigation, and communication orbit our planet. (Maini, 2018) Despite their lack of direct weaponry these satellites are critical to military operation, without the above capabilities a nation's ability to defend or attack is left crippled. The advantage to be won or lost on the destruction of these satellites makes for extremely enticing targets if conflict were to break out between space faring nations.

As a result, rapid development and testing of anti-satellite weapons is occurring all over the world, and with every single destructive test a wake of equally destructive space debris is left orbiting our planet for decades to come. The question moving forward, how will the orbital environment be sustained into the future, when nations can receive a strategic advantage at the expense of increasing space debris. Wicked problem theory is used to frame the singular issue of space debris across the innate complexities of international relations and modern-day conflict.

Methods

Methods used in this research paper include case-studies, wicked problem framing, and annual data and strategic report analysis. Key words used in research include: space debris, international tensions, ASAT, space weapons, and space law. The research of this paper is laid out in four distinct sections to include; Analysis of space debris accompanied by predictive models for future growth, collision consequences and expected frequency. An overview of current international regulations, space law, and best practices. The development of space actors' to include their history in the domain, their unique perspectives, activity, and how they interact and cooperate with one another. The final section synthesizes and evaluates, conclusions from the previous three, to propose appropriate actionable measures towards sustainability in outer space answering the following research question, how will the orbital environment be sustained into the future, when nations can receive a strategic advantage at the expense of increasing space debris?

Space Debris

Space debris is defined as any man-made object left in orbit that no longer provides a function. Ranging in size from a broken satellite all the way down to a paint chip (Gregersen, 2022). Primarily located in Low Earth Orbit (LEO) the debris travels at over 18,000 mph, for context a paint chip is lethal if contact is made, larger items such as a screw or bolt can damage other satellites creating more debris. This phenomenon was critically analyzed by a NASA scientist named Donald Kessler dubbed, the Kessler Syndrome. In detail the theory concluded that LEO will become in-hospitable, as space debris would reach a large enough density that debris will be created faster than it can de-orbit, due to an increasing number of random collisions leading to exponential and unstable debris growth. The theory continues to hold as our Orbit becomes exponentially cluttered with over 27,000 trackable pieces in 2019 (Daehnick & Harrington, 2021) with the number growing to over 47,000 in 2022 according to the U.S. Space Command Gen. James Dickinson. (Erwin, 2022)

Satellites themselves hold many capabilities, military and commercial alike. In day-to-day life a satellite's function is used many times over. These are basic functions so ingrained into the average life that chaos would ensue without them. For example, the cereal one eats every morning. The grain is produced using radar satellites to find the most opportune time to irrigate and harvest a field. The grain is then on-loaded onto a truck, car, or ship to be transported. The transportation relies on the GPS satellites to navigate across the nation and waterways. Then the merchants must buy and sell the product through its many stages ending with the consumer using a credit card at the local grocery store. All these banking transactions were able to be processed using the connectivity services provided by satellites. (CSA, 2018) Military capabilities include providing the GPS for vehicles and ground movements, guidance for advanced weapons, missile threat detection, reconnaissance, and the list only goes on. The satellites are vulnerable targets with limited physical defensive capabilities and experience constant cyberattacks (Peeters, 2022)

ASAT Testing

Intentional Anti-satellite (ASAT) military tests have contributed the sharpest increases in space debris. The three main contributors to the debris include the United States, China, and Russia. Accounting for the majority of ASAT tests and debris created (Sheetz, 2021). The military power houses aside, these nations have developed their scientific space programs alongside one another for the past 50 years. Notably, Russia and the U.S. have been working cooperatively within the scientific and explorative fronts, sharing the burden of maintenance and travel to the International Space Station for over two decades. Military relations however are tense across all nations with a significant influx of commercial and military satellites in orbit or with plans to launch, space has been recognized as a contentious and expanding domain. (Blanc, 2022) Earmarked with the continued ASAT tests from Russia, the creation of the Space Force from the U.S., and most recently the Chinese weather balloon test being shot down by the

U.S.(Garamone, 2022). Tensions are rising and space will be the initial battleground for many countries.

Wicked Problem Theory

Wicked Problem theory was created in 1973 by two UC Berkeley professors of design, Horst Rittel and Melvin Webber. The theory was created in order to address complex issues of planning with ambiguous goals and solutions, as there is no definitive way to solve the problem. In their publication *Dilemmas in a General Theory of Planning* they lay out the ten characteristics of a wicked-problem; there is no definitive formula, there is no end, the solution can only be good or bad, there is no immediate test to a solution, subsequently every attempt to fix a solution must count, there is no enumerable set of solutions, it is always unique, the problem itself could be a symptom of another, the choice of explanation determines the nature of the problem, the planner has no right to be wrong. (Rittel & Webber, 1973). These ten characteristics begin to define and highlight the ambiguity of each problem as too complex to solve but efforts can and should be made to better the problem continuously. Pollution, nuclear weapons, crime, or space debris can all be considered wicked problems as they will never truly end or be solved but efforts can be made to help better or worsen the status quo. Conflict itself is so broad and vast that to begin planning a potential solution to a product of it such as space debris, it requires a wicked theory framework.

In the publication *Wicked problems in space technology development at NASA* by Tibor Balint and John Stevens, wicked problem theory is used to analyze the budgeting problems NASA experiences, causing lulls in space exploration. (Balint & Stevens, 2015) They are able to effectively contextualize the problem by evaluating each wicked condition and explaining each corresponding factor surrounding the issue. In addition, they use a broad comparison of stakeholders to show the governmental complexity surrounding the funding to NASA and their missions, for example the cyclical issues such as annual allocations and political red-tape. The paper works through the connections between the various stakeholders to set the foundation for negotiation and compromise in order to further technological development without unnecessary chokeholds from hierarchical stakeholders that have little to nothing to do with the continuation of development. This paper lends itself well to branch off into Space Debris as a similar problem, as any attempt to a solution will be done so politically on the world stage but will continue further delving into the international stakeholders and their perspectives regarding national defense and security.

Results and Analysis of Space Debris and International Stakeholders

The strategic advantage gained through control of outer space is invaluable to the success of modern militaries. Since the beginning of the industrial revolution, destructive and effective weaponry have won wars and defended nations, simultaneously destroying surrounding environments by polluting soil and water with harmful poisons, toxins, metals, and radiation (Weir, 2023). Previous wars were fought on land and sea, limiting effects to localized environments that can heal within decades. However, outer space has little resilience to disruption and cannot recover so easily or even locally, as space debris is a substantial global pollutant, orbiting the earth every 90 minutes for multiple generations to come. Space debris is already at a significant level and the probability of collisions only increases as more fragments are created, left un-checked debris will continue to grow as debris fields expand inducing continued collisions at a faster rate than pieces can de-orbit. The U.S. and China are two of the main actors within space and major contributors to the debris problem. Tensions between the two on land are only perpetuated in space as both sides struggle to find common ground and a way forward with the militarization of space. These tensions further the debris problem with destructive testing or shows of capability, and an increase of space traffic and launches that ultimately increase the potential for collisions. As active military satellites are enticing strategic targets, placed in an environment where debris cannot be easily recovered or removed. The sustainment of the orbital environment will require strict regulation and international cooperation to include tangible sanctions against violators, continued dedication to the development and deployment of debris removal technologies, and an understanding of each stakeholder's perspective to prevent and limit the potential for conflict.

Probability of Collisions and Future Growth

What are the consequences as the orbit stands? As of January of 2023, 30,000 objects, 10 cm in diameter or larger are cataloged and tracked in LEO by the DoD's Global Space Surveillance Network, including 5465 active satellites as of May 2022 (UCS, 2022). An additional 900,000 smaller pieces, known as lethal non-trackable debris 1cm to 10 cm in size, are predicted to be in orbit with destructive ability. Nearly half of all trackable debris was a result of three previously noted incidents, including two military tests (DIA, 2022). The Chinese destruction of its own weather satellite Fengyun-1C in 2007, the accidental collision between U.S. communications satellite Iridium 33 and an inactive Russian satellite Cosmos 2251 in 2009, and the 2021 Russian Nudol ASAT test. (DIA, 2022). Focusing on the 2009 collision, active satellites hold some ability to re-position and avoid space debris, but many have become in-active through use, neglect, or debris collisions making them derelict such as the Cosmos 2251. These satellites are large and carry massive potential to increase the space debris population if collisions were to occur. The probability of similarly sized un-predicted collisions occurring due to the orbital patterns of various satellites that are no longer operable or maneuverable are displayed below in Figure 1.

Massive Derelict Cluster Collision Probabilities

Cluster*	In-Cluster P_c** (Per Year)	In-Cluster P_c Increase by 2030	No. of Likely Catalogued Fragments	LNT Likely Produced	Comments
C615	~1/280	5–7%	~5,500	~80,000	Short-lived debris (years to decades). Near many satellites.
C775	~1/715	2–3%	~4,500	~70,000	Moderate-lived debris (decades). Near many satellites.
C850	~1/800	8–15%	~15,000	~225,000	Long-lived debris (many decades). Fewer satellites than C775 or C615.
C975	~1/120	16–26%	~3,500	~55,000	
C1,500	~1/5,000	~1%	~6,000	~75,000	Very long-lived debris (many centuries). Not near many satellites

** Cluster number represents orbital radius to the center of the cluster in kilometers, for example C850 is centered at 850 kilometers in altitude*
*** P_c is probability of collision*

Figure 1: Massive Derelict Cluster Characteristics and Collision Probabilities (Rossi., Petit., & McKnight. 2020)

Figure 1 highlights the small probability of a collision, the expected number of fragmented objects to be produced, and their subsequent orbital lifespan. The severe damage caused by one large collision, similar to an ASAT test, can roughly induce a 20% increase in trackable debris and a 10% increase in LNDs. The importance of these predictive models for this research is to highlight the potential for damage, due to a collision caused by military action. Direct tests and attacks outright destroy a satellite, guaranteeing a collision and debris production. The more frequent non-kinetic cyber-attacks such as direct energy attacks blind or over-heat a satellite to leave it un-maneuverable and un-functional, crippling military and civilian assets alike (Fetter, 1988). Once crippled these satellites join the derelict clusters previously mentioned, increasing the size of the cluster and consequentially the probability of a future un-intended collision.

Looking forward to the future condition of space debris, the IADC produced the following predictive figures using Monte Carlo simulations and extrapolated satellite traffic data.

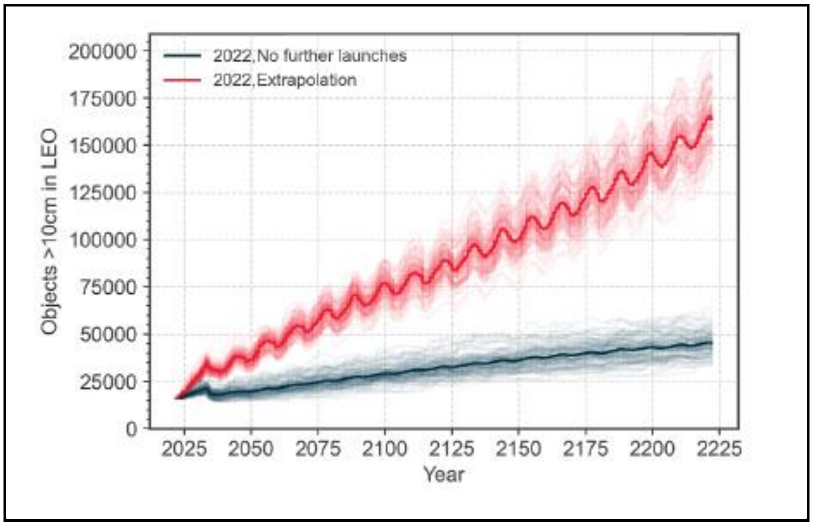

Figure 2: Number of objects larger than 10 cm in LEO in the simulated scenarios of long-term evolution of the space environment (IADC, 2023)

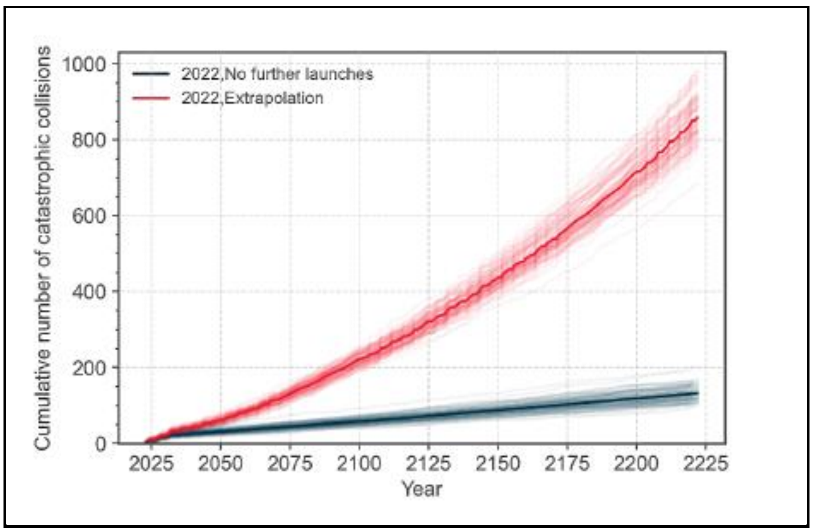

Figure 3: Cumulative number of catastrophic collisions in LEO in the simulated scenarios of long-term evolution of the space environment (IADC, 2023)

Figures 2 and 3 are based on two future worldly scenarios, the continuation of launches and no future launches. It is shown in Figure 2 that the number of objects or debris larger than 10 cm continuously grows in a positive linear trajectory against time, the slight oscillation occurring due to the natural de-orbiting of some debris in lower orbits. In both scenarios growth is positive but with a significantly lesser rate under the un-realized no future launch scenario. In Figure 3 it is shown that expected catastrophic collisions or collisions that result in the complete destruction of both target and impactor, will grow at an increasing rate (IADC, 2023). These predictions emphasize the open-ended nature of the problem, and the subsequent need for sustainable practices and engineering moving forward. As with future military action aside, the best-case scenario, debris will continue to be created faster than it can de-orbit, with no stopping rule to determine when the problem can be completely solved as the removal of all debris is nearly impossible and cumbersome to measure due to the significant amount of lethal non traceable debris in orbit. Unchecked growth will incubate LEO pollution further and make the removal of space debris more difficult and extensive, dampening space use for all.

International Regulations

Outer Space in its entirety can be claimed as Res Communis, translated to “common things” and legally to be owned by no entity but subject to use from all. The legal standard was set forth by international law in the Outer Space Treaty of 1967 (OST), as space was determined to be a common heritage of mankind and free for use by all (Svec, 2022) Meaning no nation can claim ownership or sole legal authority over any part of space or celestial object. However, when no entity can claim complete ownership, neither can full accountability be attributed to any one party. Tragedy of the Commons, a phrase coined by American ecologist Garrett Hardin, refers to a situation in which a public resource is made available to all, but individuals or groups will act in their own best interest, ultimately depleting the open resource (Spiliakos, 2019). A multitude of nations and militaries, all of which have an obligation to act within their respective interests and protect their citizens, have become the new tragic actors within space. The obligation coupled with the lack of regulation to military activity has put the sustainment of the orbit at risk, as countries act within their own best interests over the common “universal” good.

The OST set foundational principles on how a nation should act in space. Primarily banning weapons of mass destruction from being hosted in space and an expectation that space be used for peaceful purposes exclusively. Nuclear weapons certainly a prevalent issue at the time, but the writers could not foresee the future potential space held in modern warfare. Stewardship was at the backend of the treaty and it was intended that each nation avoid harmful contamination of space. (ISL, n.d.). Nations have interpreted the treaty loosely to allow for various military activities and tests following the ratification, using various legal definitions of "peaceful" to be discussed later from each stakeholder's perspective (Hammack, 2021).

Loose interpretations and questionable actions are a direct consequence of weak or non-existent regulatory bodies and enforcements. Space debris is becoming an exceedingly prevalent issue and has garnered significant attention from the international community. The following measures have been taken on an international scale to help sustain outer space. The United Nations Space Debris Mitigation Guidelines developed by the Committee on the Peaceful Uses of Outer Space (COPOUS), present the following 7 key guidelines to mission planning and execution for space missions to include;

Guideline 1: Limit debris released during normal operations

Guideline 2: Minimize the potential for break-ups during operational phases

Guideline 3: Limit the probability of accidental collision in orbit

Guideline 4: Avoid intentional destruction and other harmful activities

Guideline 5: Minimize potential for post-mission break-ups resulting from stored energy

Guideline 6: Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission

Guideline 7: Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission (UN, 2010)

The Inter-Agency Space Debris Coordination Committee provides a forum of communication between all space agencies with a scientific approach, providing further specifications, updates, and guidelines for best practices similar to those of the COPOUS (IADC, 2020). Their research, previously presented above, helps guide policy change and actor requirements. These guidelines have been adopted by many organizations and nations as best practices to reduce debris and are a step forward in building a resilient space system. In the end they are guidelines that act as a part of the solution and have a positive impact on the problem but are not codified laws with enforced compliance, leaving room for negligence if the actors so choose.

The shared characteristic amongst all current international efforts is a lack of accountability, reckless actions are condemned or receive public backlash but without legitimate consequence. For example, the Russian test in 2021, sparked controversy and was deemed "dangerous, irresponsible, and concerning" by multiple countries to include; The U.S., France, Germany, and the UK. Russia however received no recourse past these criticisms and the call for a ban on testing again echoed across the world (Maya, 2021). The International Space Station however faced very real consequences as astronauts sought shelter and maneuvered the station to avoid an incoming cloud of debris caused by the test (Potter, 2021). Simply there exists no governing body or law that can enforce, punish, or regulate space activity internationally. If a nation is to be held accountable for its action's all countries must ban together to place various sanctions and punitive actions to discourage future testing and space warfare. The furthest development of this solution locally for the U.S. is the Space Debris Bill 2022, proposed by Marco Rubio, which requires the President to impose visa- and property-blocking sanctions within 30 days, on foreign countries or actors that create debris purposefully or negligently without prior notification. The bill has yet to be passed (Rubio, 2021).

Conflict over Space as a Domain

To create appropriate treaties, the history and current status of major stakeholders must be analyzed. China, Russia, and the U.S, are the three largest stakeholders in space and the main players in its militarization (DIA, 2022). These countries are not strangers to extended periods of cold conflict between one another as tensions rise and fall between the three periodically (Norling, 2007). In order to prevent direct conflict within space, a power balance must be continuously maintained, akin to nuclear weapons and the mutually assured destruction (MAD) associated with their use. MAD keeps nuclear powers at bay by imposing stability as a necessity for survival, the idea being that if nuclear weapons are used neither strike before retaliation and neither side would survive. The stability through the presence of the weapons, provides protections to any country that has nuclear weapons and direct allies. If one country gains a significant advantage over the other an in-balance occurs, causing unrest and instability as mutual destruction is no longer assured. Rapid development is quickly prompted in order to catch up and eliminate the advantage. A disruptive example would be current hypersonic cruise missile development, which due to its non-parabolic trajectory, eliminates the effectiveness of current supersonic missile defense systems. Prompting a race in technological offensive and defense capabilities between China, Russia, and the U.S., tangential to diplomatic efforts (Wilkening, 2019). Shifting focus towards the orbit, as military and commercial satellites continuously launch, each actor gains more of an influence and stake in space. Incentivizing strong protections, demonstration of force, and a potential arms race. The debris problem can then be characterized as a symptom of increasing space traffic, growing tensions, and desired protections between space actors. The orbit can be ruined and destroyed for all of humanity's national, scientific, and private interests. As such, space sustainment should be interpreted as a potential domain for MAD and handled in an equivalent fashion. MAD would come at the hand of a Kessler Syndrome inducing event, due to an excess of catastrophic collisions. Plainly no military can outpace the other maintaining complete supremacy. So as long as militaries are able to cripple one another's space assets in the same amount of time, nations are deterred from acting against one another, as they lose a first strike advantage (Morgan, 2010).

The capability and systems to create massive amounts of debris are proven effective and will always exist, so incremented steps must be taken to better the situation and limit the impact of future actions on the environment. These weapon systems are not exclusively available to space actors either with strategic incentives from all nations to produce ASAT weapons as a viable tool to use when wrestling for control over the domain, seeking an advantage on land, or are simply backed into a corner. The problem can never cease to exist but stakeholders' interests, are analyzed below, to be balanced against one another on an international stage reaching a mutually beneficial way forward. In this research China and the U.S. space activities are compared.

U.S. Perspective and Military Activity

The U.S. has historically interpreted "peaceful" in the OST to be non-aggressive and justified placing deterrence and defense-based assets in orbit without any legal violations (Wortzel, 2007). Uniquely the U.S. relies the heaviest on their space assets to conduct traditional warfare. This dependency has accelerated internal measures to protect and deter satellite attacks (DIA, 2022). Earmarked in 2019 with the creation of the United State Space Force (USSF), to separate and further develop the space mission previously accomplished by the U.S. Air Force.

The USSF mission is publicly stated as, “The U.S. Space Force is a military service that organizes, trains, and equips space forces in order to protect U.S. and allied interests in space and to provide space capabilities to the joint force. USSF responsibilities will include developing Guardians, acquiring military space systems, maturing the military doctrine for space power, and organizing space forces to present to our Combatant Commands.” (USSF, n.d.). The service's intention is clear, to defend U.S. interests while providing options to achieve national objectives, including defense, with an estimated 237 military associated satellites in operation (USC, 2022) To protect U.S. interests actions may be taken to protect these satellites and outpace Chinese development, to maintain supremacy in space.

Chinese Perspective and Military Activity

Early rejector’s to the militarization of space, interpreting “peaceful” intentions in the OST to “non-military China was slow to develop their military utility of space for the latter half of the 20th century” (Wortzel, 2007). In the 21st century China has shifted its attitude with rapid launches of military satellites and introduced space specific military doctrine, to include their 2019 national defense aim “to safeguard China’s security interests in outer space, electromagnetic space and cyberspace” (Erikson, 2019, pg. 7). Following this shift, China nearly doubled the amount of military satellites from 2019 to 2021 reaching nearly 500 military or military supportive capable satellites (DIA, 2022). By 2022 a dedicated effort was proven, as China outpaced the U.S. and Russia in defense class payloads with a total of 45, compared to 30 and 15 respectively (McDowell, 2023). China’s actions have made it clear they intend to produce the capability to contest with the U.S. in space and protect their own national interests. Significantly, prompting other actors to match and compete with their growth, signaling the start of an arms race that would only continue LEO debris creation as a symptom of their growth. (DIA, 2022, pg. 42).

Space relationship between China and the U.S.

The 2007 anti-satellite test helps explain the strategic and diplomatic relationship between the two countries that has led to the continued pollution in space. In 2007 China displayed it's intent to become a main actor within space, the anti-satellite test acted as a show of force, proving China's destructive capability. One year later, with a debated diplomatic or strategic intent to demilitarize space, the Treaty on the Prevention of the Placement of Weapons in Outer Space and the Threat or Use of Force against Outer Space Objects (PPWT) was proposed by China alongside Russia. The treaty attempted to further define space weaponry but failed to acknowledge or ban ground to space ASAT weapons, similar to the one tested a year prior. The U.S. viewed the treaty as crippling to their already existing military operations while skeptical how it will be enforced internationally, with no instilled conditions or inspections to verify a satellite's weapon system potential or activity. Both sides claimed their intentions were to provide sustainability, but are unable to find any compromise as strategic objectives outweigh the initially peripheral consequences of the debris (Listner, 2011).

In 2021, over a decade later, as debris worsened The U.S. imposed a self-moratorium on collision-based ASAT tests under the Biden Administration. Codifying the unofficially held sentiment since their own ASAT type test in 2008. The moratorium is accompanied by a call to instill a "new international norm for responsible behavior in space" ending destructive testing seen by all nations in the past. Russia and China have not followed the U.S.'s lead, despite early attempts to ratify the PPWT a decade prior (Panda & Silverstein, 2022). There is no clear or direct solution to appease both sides, no one nation is right or wrong and they participate in a legal game of interpretation and intimidation: in which neither side wishes to engage or commit to the other, at the consequence of tying their own hands while the other is able to pull closer or farther away. The supposed public focus of both nations is sustainability, but it is clear strategic advantage can be gained even through the "metaphorical crippling" of a stakeholder's assets through legal impositions, leaving the path forward with no legal regulation, as both continue to build their space portfolio without regulation. The future problem outside of the debris then becomes whether current actors will allow for a regulatory body to come to fruition without their unique interest being represented and protected against other actors. As in the end, actors identify each other as adversaries and not fellow stewards, placing crosshairs on satellites, escalating tensions, and taking actions that threaten res communis principles, exacerbating the potential for debris.

The Solution and The Way Forward

Space debris as it stands will not fix itself, The IADC has concluded that compliance to mitigating debris guidelines has slowed down current additions to the population but will not be enough to begin decreasing it. (IADC, 2023) The technological solution forward is active debris removal. Engineering must be funded, developed, and employed by the current actors so that they may be held responsible for their past actions and be prepared for future incidents. There is no complete solution or stopping rule to the problem as the removal of all debris and potential for collisions can never be accomplished whilst actors remain in space and thousands of pieces are never recovered. Therefore, the solutions proposed ahead can only better or worsen that status quo.

On the contrary, no amount of mitigation or removal of debris will be effective in the case of direct conflict or continued collision testing. Compromise, regulation, and definitive action must be taken by all actors to include; an international consensus to end collision-based ASAT tests and furthermore take aim off one another's satellites. Compromise could take form in a new weapons treaty, with a future target placed ahead of the current status-quo for both countries, so that the nations can work towards but not go over defined limits, reducing the potential for a space arms race. The treaty would allow for China and the U.S. to maintain current "stockpiles" and work towards a shared capability appeasing U.S. concerns of crippling their assets and alleviate Chinese concerns of U.S. dominance. To address all actors not just China and the U.S., accompanying modification to the OST will be required. Modifications that can explicitly define what militaries can and cannot do, setting appropriate expectations, limiting destructive testing, and reducing the risk of an attack in itself, providing a positive impact on the open-ended issue of debris. Finally, once the initial groundwork above is accomplished and compromise achieved, the creation of a regulatory and investigative body with true authority can be instilled to hold actors accountable for future catastrophic collisions. The regulatory authority would be able to place sanctions and economic fines to fund debris removal research and missions. These actions will be the first step towards reaching stability in space and stopping unnecessary spikes in pollution, but nations can not delay action waiting for definitive proof that the solutions will work as you can not test the impact of these steps for many decades.

Further research should be placed in the specific defensive and offensive capability of satellites and how those new potential features can affect the stability of space operations, to include increased resilience properties such as maneuverability and physical shielding. In addition, a continuation of this research could include a financial and competency evaluation of debris removal technologies, to present associated costs and funding requirements for governments, so that they may directly pay for their current and future damages.

Conclusion

In conclusion, the research proposes the appropriate measures and methods towards understanding the militarization of space and the consequences the orbit faces as an environment if it continues unbalanced. Space debris is increasing at an unsustainable rate. Actors are unable to hold one another accountable. Militaries are given next to free-reign to expand over the domain. By imposing international regulation on actor nations through ratified treaties, working towards diplomatic compromise, and developing new debris removal technologies, the rate at which space debris is produced will be decreased. If compromise, efforts to remove debris, and definitive action are continuously avoided, the LEO will become overcrowded and in-hospitable. Threatening the agriculture, navigation, banking, and communication satellite capabilities much of the world relies on for day-to-day life.

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