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Terror on High: Deterring ASAT

Stephen Shea, Mathew Johnson, and Alfredo Zurita

Layered deterrence and carrot-and-stick diplomacy are the main ingredients for deterring ASAT.

As technology becomes even more pervasive in daily life, valuable and relatively vulnerable space assets will inspire greater desire to attack U.S. power through space.[1] As a result, Anti-Satellite (ASAT) deterrence, a fledgling area of study, will need to be developed and addressed in detail. The proceeding essay will attempt to answer the following questions. What motivates space attacks? How will the enemy try to attack our space assets? What can be done to deter future ASAT attacks?

REASONS TO ATTACK SPACE ASSETS

Despite the precedent of peace in space, there is still the worry that these assets will be attacked. These fears are justified for several key reasons, including the limited orbital slots available for satellites and common designs among adversaries to blind the United States, challenge American hegemony in space, and fashion an asymmetric response to U.S. military actions. While no nation has of yet struck another nation's space assets, the capability to do so has been repeatedly demonstrated.

As the need for global telecommunications continues to rise, the space available in Geosynchronous Orbit (GEO) becomes smaller and more valuable. As of February 2014, there were 391 satellites active in GEO.[2] The current issue with this orbital region is that, while the satellites are not in significant danger of hitting each other, there is a required level of separation between assets to ensure there is no interference or overlap in telemetric frequency. Mission and environmental requirements cause GEO satellite contracts to cost well into the billions of dollars; each of these represents a significant investment for corporations as well as the host nation. Moreover, countries near the same longitude will desire the same sliver of the GEO ring and will have to voice their arguments to the International Telecommunication Union (ITU).[3] Losing this competition over a scarce resource could lead to ASAT attacks from certain leaders. If done a certain way, ASAT could incapacitate valuable regions of GEO.[4]

Historically, one of the driving factors in the research of space technology is the military benefits. One of these benefits is the capability to observe an enemy nation without an air-breathing platform, that is, without the risk of a pilot's life or materiel. Knowledge of troop and equipment movements, for example, is invaluable during war; therefore, a nation has strong incentive to disable an enemy/rival nation's space capabilities through ASAT methods. The incentives only increase for utility satellites such as those of the Global Positioning System (GPS) that aid weapon targeting and ship movements.

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[2] Eric Johnston, List of Satellites in Geostationary Orbit, last modified February 21, 2014, http://www.satsig.net/sslist.htm, (accessed April 23, 2014).

[3] Graham Templeton, "What is Geostationary Orbit and Why is it so Important?" last modified December 14, 2013, http://www.geek.com/science/geek-answers-what-is-geostationary-orbit-and-why-is-it-so-important-1579225/, (accessed April 21, 2014).

[4] If satellites are destroyed in a manner that causes large amounts of debris, the debris would occupy valuable geostationary orbits.

With the U.S. having launched approximately 40% of the satellites currently active today, it holds the global lead for investment in space assets.[5] Some space experts and U.S. political advisers have reasoned for the U.S. domination of space. In short, they have argued to make space a U.S. controlled resource and to selectively choose who can and cannot gain access.[6] Such a statement is clearly unsettling to other national space agencies. These agencies are already occupied with internal politics and funding. Having outer space policed would cause great distress and international strife. The level of discomfort could result in other nations pushing back against the hegemon of the space domain and attempting to destroy U.S. military or commercial assets. Indeed, if the U.S., or any other nation for that matter, were to decide it would be the arbiter of what is allowed in orbit, one of the first logical steps would be to clear any opposition assets from the newly claimed area.

An additional reason nations may attack space assets would be in retaliation for military actions. These actions may or may not have been space-related to begin with—they could involve 'cross-domain' coercion--but an aggrieved nation might see fit to retaliate against the attacker nation's space assets. These nations may resort to ASAT operations, at a minimum to blind partially the attacking nation and thus curb the effectiveness of the original attack. In any case, before long, both nations involved may be utilizing ASAT capabilities and, as such, they will be interested in counter-ASAT capabilities to protect what remains of their own resources.[7]

[5] Union of Concerned Scientist, UCS Satellite Database, http://www.ucsusa.org/nuclear_weapons_and_global_security/solutions/space-weapons/ucs-satellite-database.html#.VP0Jg_nF9p8, (accessed March 8, 2015). Peter Apps, "Global spending on space falls, emerging states are spending more," http://in.reuters.com/article/2014/02/13/space-spending-idINDEEA1C0I120140213, (Accessed March 8, 2015).

[6] Michael Cooney, "US Lab Developing Technology for Space Traffic Control," last modified January 23, 2014, http://www.networkworld.com/community/blog/us-lab-developing-technology-space-traffic-control (accessed April 20, 2014). Dolman, Everett C., *Astropolitik: Classical Geopolitics in the Space Age* (London: Frank Cass, 2002).

TYPES OF ASAT TECHNOLOGY

Before international actors can become a threat, they need more than just the desire to destroy U.S. space assets. They need the capability. However, this is easier than it appears, for there are a multitude of ASAT methods, which can be condensed into five types: signal/intelligence disruption, terrestrial attack, kinetic annihilation, rendezvous disabling, and electromagnetic pulse.

The most accessible type of ASAT capability is signal/intelligence disruption. The easiest method of countering space assets is jamming, for it can be done with simple equipment for a low cost. This is useful to disadvantaged actors but has much lesser effect than other types of attack. Another ASAT method of this category is using lasers to blind optical sensors, often used by non-space powers. The last method is 'spoofing', or sending false commands. What distinguishes spoofing from a cyber-attack is that sending false commands does not involve unauthorized network access or software code manipulation.[8]

All of these methods are typically temporary; outside the space-time window of effect, the satellite is at full functionality. They also are traceable, due in part to their lack of destructiveness, but direct retaliation is not an option. The international community does not consider military strikes in space to be a proportional response. Countries like Iran already take part in these ASAT methods without receiving U.S. retaliation, so there already are

[7] Today, it is hard to imagine a splendid first strike that would incapacitate all or most satellites of a space power. Unlike the case of declining numbers of nuclear weapons, a nation's growing numbers of satellites are always widely dispersed and never 'in port'. After a strategic first strike—a space Pearl Harbor—there are likely to be many surviving satellites for the United States to defend.

[8] Micah Zenko, "Dangerous Space Incidents," http://www.cfr.org/space/dangerous-space-incidents/p32790 (Accessed 19 April 2014).

precedents for inaction.[9] For now, signal/intelligence disruption must be countered technologically, not kinetically or politically, through cross-domain deterrence.

Terrestrial methods for ASAT are those that attack the ground element of space operations, which includes ground infrastructure attacks and cyber-attacks. This type, while it does pose a significant threat, is covered under other realms of international law and requires different responses. Military strikes against ground stations count as attacks against sovereign soil of the targeted nation, which clearly justify military retaliation of the attacked country. Cyber-attacks involve a different operational domain than space and have different legal restrictions and military requirements than the space domain. Less formal differences between the domains include how easy it is for the aggressor to stay anonymous and who is capable of such an attack.

Multiple space powers have developed highly destructive ASAT weapons using kinetic annihilation, which include attack satellites and ground, aircraft, or ship–based antisatellite missiles. While the launch platforms of antisatellite missiles are quite different, the use and technology required are very similar. The missile is launched on a sub-orbital, intercept course and collides with a target satellite, completely destroying it. Both the United States and China have demonstrated this capability. The other developed system is an attack satellite, the Istrebitel Sputnikov. This Soviet satellite was designed to be rapidly launched from storage, approach a target satellite, and launch projectiles at the target satellites.[10] It is unclear whether Russia still holds this capacity. For both of these methods, a single collision is all that is necessary to completely destroy the target. Both of these methods cause the kinetic annihilation of the target.

The benefits of kinetic annihilation ASAT for the attacker include having the concept of operations well-grounded in a long tradition of military flight operations and, specifically, having possession, or full control and maintenance, of assets on the ground before an attack order is initiated. Most important of all, in contrast to signal disruption or terrestrial methods, if a kinetic attack succeeds as planned, the target is unrecoverable: the adversary's space platform will not be coming back online.

For some of the same reasons, this type of ASAT attack is the most critical to defend. China's 2007 ASAT demonstration created 2,300 traceable pieces of debris. This represents a significant percentage of the approximately 21,000 objects currently tracked.[11] In almost 60 years of space flight, approximately one out of nine tracked objects is debris from the Chinese ASAT event. While two U.S. ASAT tests created significantly less debris, it only takes one kinetic annihilation event like the Chinese demonstration to increase significantly the traceable debris in orbit. This does not account for all the smaller pieces of debris that can be just as damaging because all objects are traveling at incredible speeds.

While there have been few collisions in space, the odds jump with each ASAT kinetic annihilation event[12]. Without strong disincentives against this method, space will become increasingly dangerous. For both U.S. interests and the global good, ASAT demonstrations like the Chinese ASAT ought to be discouraged. Kinetic annihilation tests themselves must be deterred or at least performed in a way to keep orbital slots navigable.

These methods have a characteristic, which should make them easier to deter: they are practically impossible to hide. The United States and other nations have the ability to detect all space launches as part of their nuclear deterrence infrastructure. For this reason, outside of a hot war

[9] Micah Zenko, "Dangerous Space Incidents."
[10] Anatoly Zak, "The Hidden History of the Soviet Satellite-Killer." http://www.popularmechanics.com/technology/military/satellites/the-hidden-history-of-the-soviet-satellite-killer-16108970 (Accessed 18 April 2014).

[11] NASA.org, "Space Debris and Human Spacecraft," http://www.nasa.gov/mission_pages/station/news/orbital_debris.html#.U1KtevldWSo (Accessed on 19 Apr 2014).
[12] NASA.org, "Space Debris and Human Spacecraft."

between superpowers, this type of attack is unlikely at the moment, but still, we must be prepared for the rise of less stable actors who desire to test in prelude to more aggressive moves.

A future type of ASAT might be rendezvous disabling. Physically disabling a satellite might use any of the following methods, all of which require finely controlled rendezvous. This type requires the most complex satellites. The first method is physically damaging critical systems of a target satellite. It would be the most advantageous to use a small satellite, centimeters in length at most. This method could use a claw to snip off solar panels or antennas, which could either kill the electrical power system or mute the communication system. Even less invasive would be snipping the connecting wires of either of these systems. This method could also use a thruster to disable sensitive electronics. Thrusting on an optical sensor would at a minimum contaminate the lens, ruining the target's capabilities.

Another futuristic method would use directed electromagnetic strike, essentially using focused electromagnetic energy to short circuit an individual spacecraft. A laser could be used to damage electronics in the same way as the claw method, cutting off components or wiring. The aggressor satellite could puncture a target with two spikes and run large voltages between the spikes. A satellite could also attack a target by sending radiation or strong electromagnetic signals to disrupt and damage the target's inside wiring and systems. These abilities are likely to be development intensive compared to other methods. This would require a less precise rendezvous, but a much higher power demand, leading to a larger satellite.

The benefit of electromagnetic strike over kinetic annihilation is the target is disabled without creating a debris cloud. This lessens the international damage and thus the backlash of such an action. International actors that would use this method will likely try to evade detection, plausible with a tiny satellite or in the correct window of opportunity. They would hope to damage vital space assets free of accountability like actors do in the cyber realm.

For many systems, it may be impossible to damage wires without disconnecting the component, but if an actor is able to damage wiring or internal systems, an attack could be hidden as a spacecraft malfunction. Close inspection of satellites, which may be the only way in some cases to tell the difference between attack and malfunction, is expensive and difficult due to the nature of the space environment. Whether a component is damaged or cut off, it is most important to know rapidly two things: that an attack actually took place and the identity of the attacker.

The last and least likely type is an Electric Magnetic Pulse (EMP). The only known human cause of an EMP is nuclear weapons, discovered during high-altitude nuclear tests in the 1960's.[13] Even limited powers in the space and nuclear arenas like North Korea might be capable of an EMP, but limited nuclear materials also make a secondary target like space unlikely. Nuclear weapons would be much more devastating to ground targets. Also, nuclear detonations in space are now clearly forbidden by international law and would surely bring the wrath of most powers around the world, particularly space powers that would be damaged in the attack.[14] Space powers have even greater disincentive because they would be directly damaging themselves. If non-nuclear EMPs are possible, the best delivery would be similar to rendezvous attack, with a smaller area of effect due to power constraints and ability to focus against individual satellites.

Each of these ASAT methods holds a different challenge to deterrence. Signal/intelligence disruption will not be covered by most deterrence methods because of its low permanent impact to space assets. Terrestrial and EMP attacks spill over into other national security realms, so they will at least be partially included in standard

[13] "Nuclear Weapon EMP Effects," http://www.fas.org/nuke/intro/nuke/emp.htm (Accessed on 19 April 2014).

[14] UNODA, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, http://www.unoosa.org/pdf/publications/ST_SPACE_061Rev01E.pdf, (accessed March 9, 2015).

deterrence strategies. The ASAT types most critical to deter, today, are kinetic annihilation and rendezvous disabling. Building international consensus against kinetic annihilation will be easier than rendezvous disabling due to kinetic attacks' greater physical damage to the space environment. Yet, both are equally damaging to a peaceful and cooperative space environment.

DETERRENCE IN SPACE

Deterrence, in essence, is the act of preventing conflict escalation through intimidation, coercion, or fear of consequence. It is important to distinguish that deterrence involves avoiding attacks and should not be likened to diminishing an adversary's capabilities.[15] To establish the framework, there are three requirements for deterrence. First, the enemy must believe that their actions will be identifiable; otherwise, logic would preclude the absence of any negative consequence for the aggressor.[16] Next, the adversary must also be risk adverse. This is essentially synonymous with assuming rationality, a factor that is frequently mentioned and discussed in nuclear deterrence theory. It is impossible to deter an irrational actor who does not fear retaliation. Last and most difficult, the risk must outweigh the cost of aggression. The actor must believe that attacking will result in an adverse response with losses greater than the expected gain.

The space environment is unique and should be given distinct consideration in analysis. Space assets in low earth orbit (LEO) are moving at about 17,500 miles per hour and are subject to several extreme conditions. These conditions such as near vacuum pressures, free-fall, radiation, and extreme temperature vacillation make designing and placing assets in space exceedingly difficult. As discussed previously, the motivation for attacking space assets is there; the problem lies in preventing possible attacks. First, it is important to understand why conventional deterrence techniques might not work and what hindrances might be faced.

In addressing the first requirement of deterrence, the enemy must believe that the attack can be traced back to them. The space environment, while vast, is becoming more and more populated as technology along with the probability of accidents increase. Currently, there are over thirteen-thousand man-made objects larger than ten centimeters in diameter orbiting the Earth that are being tracked by the U.S. Space Surveillance System (SSS).[17] The SSS, in conjunction with systems at Cavalier Air Force Station and Eglin Air Force Base, provides a capability of space awareness that is both rare yet slightly limited—the systems are not infallible and have weaknesses.

One limitation of the systems in place that the enemy may try to utilize is the objects being tracked cannot be monitored for the entirety of their orbits. Instead, they are usually identified upon detection, and, using two sets of range and timing data, their orbital parameters are updated a few times per orbit. An ASAT attack could hide in the blind spots of space situational awareness. Without adequate surveillance, a sudden loss of satellite functionality or communication could be difficult to diagnose. For example, if rendezvous disabling at LEO can be conducted swiftly and during the anonymity time window, there is little to no deterrence available for the attack. The only possibility is to narrow down suspects to those who possess such a capability.

Assets in GEO are less numerous, but given an altitude of about 36,000 km, they are also harder to observe. With proliferation of advanced

[15] Karl Mueller, "The Absolute Weapon and the Ultimate High Ground: Why Nuclear Deterrence and Space Deterrence Are Strikingly Similar - Yet Profoundly Different," *Anti-satellite Weapons, Deterrence and Sino-American Space Relations* 1 (2013): 42; http://www.stimson.org/images/uploads/Anti-satellite_Weapons.pdf (accessed April 26, 2014).

[16] James Lewis, "Reconsidering Deterrence for Space and Cyberspace," *Anti-satellite Weapons, Deterrence and Sino-American Space Relations* 1 (2013): 73; http://www.stimson.org/images/uploads/Anti-satellite_Weapons.pdf (accessed April 26, 2014).

[17] "Orbital Objects, Satellites, Space Junk Information, Facts, News, Photos -- National Geographic," National Geographic, http://science.nationalgeographic.com/science/space/solar-system/orbital/ (accessed April 26, 2014).

technology, an attack in GEO could increase in likelihood with a larger window of attack, especially if the limits on GEO situational awareness endure. Also, assets in GEO tend to be more valuable due to the advantages of the orbit for communications and early warning. Anonymity is a complicating factor made larger by limited space situational awareness. There are possible windows of attack where the enemy can escape repercussions and ultimately deterrence.

The second requirement of deterrence, a rational actor, cannot be established through previous crisis behaviors; however, it may prove a surprisingly workable assumption. Stability in state actors' behavior patterns, defined by slow change, is a function of the difficulty inherent in acquiring significant space assets and technology. The likelihood of an undisciplined or reckless actor acquiring said technology is most present in stealing low-budget jammers and non-kinetic weaponry. However, with growing technology, more and more states are developing space capabilities.

In the case of North Korea, it already has a space program with a successful launch in 2012. Many believe its purpose is to develop ICBMs, but with additional testing and design, their program could be repurposed for ASAT.[18] Plus with North Korea's ties to Iran and other destabilizing actors, the spread of technology could eventually lead to space assets for kinetic attack falling into the hands of 'irrational actors' with little concern for customary constraints of the international system.

The final requirement, that the risk must be greater than what might be gained, is the most elusive. There are several unique features of the space environment that may make attacks more beneficial than was the case for nuclear deterrence on the ground. A fundamental difference between nuclear deterrence and space deterrence is the sheer destructive power of the assets involved. A nuclear attack risks both structural and more importantly human capital. It affects the adversary on numerous levels, psychologically, economically, and militarily.[19]

With a space attack, the immediate damage is narrower, to an expensive and valuable asset leading to a loss in capability such as GPS coverage or military surveillance. The gain from a strategic space strike for a technologically inferior foe may be extremely valuable in a military conflict. Due to the difference in consequences, however, the international reaction is likely to be limited in scale when compared to a nuclear attack, and, especially for a revisionist state, it is much easier to justify an attack without human casualties.

When considering a military response to attacks on a space asset, counterattack options are few. Scorn from the international community has not stopped North Korea from going nuclear, so it is unlikely to affect the spread of ASAT capability. Also, it would be hard to justify a disproportionate military attack on a space aggressor, to audiences abroad or at home, that would be severe enough to provide deterrence. With regard to proportional strikes, the attacker in a likely scenario might not possess significant space assets for the defender to retaliate against. Thus, with the increasing importance of our space assets, the gain for others in attacking them, especially without proper precautionary actions by the United States, can outweigh the cost.

Another deterring factor that exists in the nuclear realm is the so-called first-strike taboo. A possible reason why a nuclear attack has not occurred since 1945 is that no nation wants to carry the burden of first strike that could plausibly lead to a general nuclear exchange in which everyone lost.[20]

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[18] Duyeon Kim, *North Korea's Successful Rocket Launch*, http://armscontrolcenter.org/issues/northkorea/articles/north_koreas_successful_rocket_launch/ (Accessed 27 April 2014).

[19] Karl Mueller, "The Absolute Weapon and the Ultimate High Ground: Why Nuclear Deterrence and Space Deterrence Are Strikingly Similar - Yet Profoundly Different," *Anti-satellite Weapons, Deterrence and Sino-American Space Relations* 1 (2013): 47; http://www.stimson.org/images/uploads/Anti-satellite_Weapons.pdf (accessed April 26, 2014).

[20] Bruce MacDonald, "Deterrence and Crisis Stability in Space and Cyberspace," *Anti-satellite Weapons, Deterrence and Sino-American Space Relations* 1

Though this factor is probably small compared to likely nuclear retaliation, this first-strike aversion does not even exist in the space realm. The only casualty is a space asset unknown to the nation's people, and its loss may not readily affect them, depending on the satellite's purpose. While long-term effects of ASAT attacks are crippling to global infrastructure for communications and navigation due to increased debris and collisions, short-term effects do not provide significant adverse consequences. If ASAT capability exists and the need is present, neither fear of retaliation nor first-strike taboo are likely to be strong enough deterrents.

A PLAN FOR SPACE DETERRENCE

Given the uniqueness of the space domain and the hindrances to deterrence identified, actions that can be taken will require complex tradeoffs. The approach should be multifaceted, catering to powerful nations already in space and those with intentions of acquiring future space capabilities. To do this, our proposed plan incorporates a carrot-and-stick method to incentivize peaceful space operations as well as discourage ASAT attacks.

First step is we must minimize the gain inherent in any space attack. There are numerous actionable methods for the U.S. to protect itself. For example, in order to protect crucial space assets, while it will be more expensive, space platform architecture should be distributed. A valuable and strategic asset to the military is encrypted and secure communication. The capability should not rely on one robust and hardy satellite but should be conducted by a disbursed network. With added redundancy, it is more difficult for an adversary to eliminate a U.S. capability. Terrestrial assets could be distributed and buried, following NORAD, to further reduce an attacker's potential gain. These methods of distributed architecture minimize the reward of successful ASAT attacks.[21]

The hardiness of each satellite can also be increased. First of all, the U.S should continue to provide crucial assets with nuclear radiation resistance and long service lives. To combat ASAT methods, additional capabilities can be added. For example, with the expansion of microsatellites, they can eventually be made to orbit or perform proximity operations for a larger satellite. They can act as sensors and perform countermeasures to protect the larger platform. After a threat is detected, the micro-sat can be designed to respond using a variety of methods, including sacrificing itself or (someday) employing ionic fluid deflection.[22] Lastly, the micro-orbiter can be used for state-of-health monitoring and troubleshooting.

Other hardiness measures include cameras used for proximity visuals and threat detection, and mini-thrusters for additional agility. The agility is gained by having more robust onboard propulsion and control in order to navigate and avoid threats. This can be useful in protecting against some rendezvous disabling methods. Increased detection and movement could dissuade an aggressor by forcing him to meet high satellite control requirements.

Increased space situational awareness is also critical for strengthened deterrence. Upgrading U.S. space surveillance capabilities to close the holes in awareness at LEO and GEO would help hold aggressors accountable and allow for greater countermeasures. Research into this and other protective technologies should be bolstered to develop essential capabilities that increase deterrence.

Reducing the gains from attack is an ongoing effort as well as one that should be researched for

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(2013): 84; http://www.stimson.org/images/uploads/Anti-satellite_Weapons.pdf (accessed April 26, 2014).

[21] Bruce MacDonald, "Deterrence and Crisis Stability in Space and Cyberspace," *Anti-satellite Weapons, Deterrence and Sino-American Space Relations* 1 (2013): 91; http://www.stimson.org/images/uploads/Anti-satellite_Weapons.pdf (accessed April 26, 2014).

[22] Thomas Joslyn, information received by author, Rocket Propulsion Class Lecture, USAFA, May 3, 2013. Ionic fluid deflection is an experimental concept that would use vector ionic liquids as a momentum transfer medium to perturb incoming objects away from the primary satellite.

more effective technologies. However, a smaller gain may not be a complete disincentive. Therefore, a retaliatory stick is necessary for the carrot-and-stick approach to work. Denial of access to the domain itself in response to successful or even attempted aggression might instill fear in would-be attackers.

The major space powers, the United States, Russia, and now China, have the technical wherewithal to execute kinetic ASAT exercises as a demonstration of power and of their willingness to deter space attacks by punishment. However, it has not been expressly stated how these ASAT capabilities will be utilized. If an agreement were made to use this capability for denying access to the space domain for any state or entity that acts aggressively, it might provide benefits that would have to be weighed against the costs and difficulties of maintaining agreement among enforcer powers as to who, in space, were the aggressors.

Everett Dolman points out in *Astropolitik* that an international space agency could be erected to oversee all actions and efforts conducted in the space domain.[23] This is politically unfeasible; even the United States would not allow others to search its satellites, but an international agency could serve to minimize excesses of unilateralism. This organization would determine when a country has crossed the line into 'aggression' and coordinate denial of space against the culprit. It would prevent the aggressor from gaining space technologies and from launching successfully, perhaps via the interception of its rockets.

Credible prosecution of this deterrence-by-punishment system would rely upon capabilities of countries like the United States, China, and Russia. The international organization could also oversee rehabilitation and eventual recertification of previous aggressors as well as probationary inspections of launches once the aggressor is permitted to reenter the space domain. Reinstatement would need to be a stringent and lengthy process to make deterrence work against ASAT.

To earn its keep, the anti-ASAT organization could also resolve space disputes and help regulate information and materials that could be used for ASAT capabilities. It should also set regulations for the disposal of satellites that are too dangerous to reenter the Earth's atmosphere on their own. The United States already set a precedent, albeit controversial, for this in 2008. Regulations would, as an alternative to far more cumbersome multilateral negotiations, outline what is considered dangerous and who is capable of properly disposing satellites while minimizing debris.

There is at least one major complication in punishment through space denial: Most countries will not stand for an attack against a manned launch, and the United States would not want to pull the trigger in this case either. There is still some benefit to preventing just unmanned launches. Manned launches cost more because of life support equipment and supplies, and most countries' space programs are not designed to function through purely manned launches. At a minimum, the aggressor country at least suffers additional economic cost for continuing a space program—even if manned launches are excluded from punishment.

Another objection to the "stick" of punishment by attacking unauthorized launches is that it is too risky for those that enforce denial of space access. Yet, as was the case for classical deterrence, harsh consequences are the only way to convey that the space domain is really protected and that assets should not be marginalized. One of the key principles of nuclear deterrence is still the risk of nation-ending destruction. While space does not have such an extreme without nuclear weapons in play, having a risk of escalation and punishment is needed to deter an aggressor in the first place. The aggressor must see the possibility of severe punishment as part of what makes the cost of ASAT too high to be worth the potential benefit.

For the carrot in this proposed plan, it is also important to incentivize peaceful space operations. There are many methods to approach this, some

[23] Everett C. Dolman, *Astropolitik: Classical Geopolitics in the Space Age* (London: Frank Cass, 2002).

already in place. First, international partnerships with not only nations maintaining large programs but those with smaller initiatives that might be pooled should be established or bolstered. The International Space Station is a prime example of the successes achievable through international efforts. The ISS acts as a stabilizing agent through the concept of self-defeat.[24] For example, if a country that participates on the ISS wanted to also conduct an ASAT attack on an asset in LEO, they might be dissuaded by the prospect of endangering their own assets whether human or technical. Also, such an attack would immediately jeopardize all programs conducted in the international effort due to repercussions that would follow.

Difficulties with "space aid" that may be anticipated include supplier restrictions on the distribution of proprietary information, as well as incompatible commercial or security interests among competing sovereigns, and endemic fiscal limitations. For this kinder, gentler approach to work with the United States as a spearhead, a reinvigorated interest at home in the space effort must be seen followed by an increased budget for space.

Another method of incentivizing budding space ventures as well as peaceful operations abroad could be offering other countries access to space assets in return for support in joint operations and work to improve their own space programs. Assets such as satellite communications, GPS, and satellite entertainment are very desirable to nations that do not currently possess said technology. This carrot has the potential to realize a global community committed to peaceful operations as well as effective, and profitable, space ventures through synergistic and cooperative efforts.

Ultimately, international commitment is critical to successful space deterrence. Deterring ASAT should not be a solely U.S. endeavor if its purpose is to sustain a peaceful environment for all nations. There is incentive for many nations to join a regime that includes both the carrot and the stick. Implementation of this plan requires an enormous international effort and will not be settled upon immediately.

At the same time, the harshness of the stick in this plan should not be alleviated in order to reach a watered-down, multilateral consensus. A true consequence needs to be established that will effectively deter ASAT attacks as the space domain becomes more and more accessible and the possibility of attack increases.

Also, peaceful access to the space domain should be promoted and proliferated. The proliferation of space assets can be stabilizing, a parallel to Waltz's concept of nuclear deterrence when every state accepts that something it values dearly is being held hostage, as collateral for good behavior.[25] Cooperative efforts, access to valuable space services, and induction into an elite group can be extremely exciting and motivating for a developing country.

Assuming success with an overwhelming majority involved in this international and eventually global space posture, the environment could be extremely intimidating, indeed forbidding, to a prospective aggressor. The hope is that in the long run, carrot-and-stick arrangements transition from a deterrence method to a governance system for establishing and maintaining stable and reliable access to space for the global community.

CONCLUSION

Space is, and will continue to be, a critical environment for both civilian and military operations. Due to its value to the United States and other nations, there are strong incentives for technologically inferior challengers to disrupt and destroy space assets. As more countries gain space capabilities, the environment will continue to become more crowded and more complex. It also has the potential to become more dangerous, for there are numerous ASAT methods that need to be deterred.

[24] Michael Krepon, "Space and Nuclear Deterrence," *Anti-satellite Weapons, Deterrence and Sino-American Space Relations* 1 (2013): 27; http://www.stimson.org/images/uploads/Anti-satellite_Weapons.pdf (accessed April 26, 2014).

[25] Scott Sagan and Kenneth Waltz, *The Spread of Nuclear Weapons: A Debate* (New York: W.W. Norton, 1995).

An effective way forward consists of three parts: reducing the gain of ASAT; brandishing a stick for aggressors; and offering a carrot for peaceful sharing of the space environment. The most effective way to minimize the gain of ASAT attacks is distributing the space architecture. Using disbursed fleets of many satellites significantly lessens the impact of one ASAT attack. The stick punishing aggressors is subsequent denial of their using the space environment. Denial might be coordinated and executed by an internationally established space agency, which would take responsibility for shooting down aggressors' space launches, restricting technology from rogue actors in space, and sanctioning individuals involved in violating space law and regulations. Equally important is the carrot: building relationships between national space agencies and working on joint projects. Major projects like the International Space Station deepen ties between countries even when earthbound issues create tensions.

Deliberation and agreement among countries, particularly space powers, is vital to both the carrot and the stick of deterring ASAT attacks. The process should be led by the United States but will be useless without international buy-in. Compromise is necessary, but toothless agreements to attain a putative consensus will be ineffective. The world needs a peaceful and cooperative space environment, and the sooner an effective method of deterring ASAT is established, the closer we will be to a better future for both the United States and the whole of mankind.