Denying PRC benefits from attack on United States' Satellites

Price School of Public Policy and Viterbi School of Engineering, University of Southern California

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Responding to a PRC Attack on U.S. Satellites

Although many strategists believe conventional warfare between great powers is improbable or "anachronistic" due to mutual nuclear capabilities and the modern interdependent global economy, outbreaks of war do not always follow such logical predictions, and the United States must be prepared for a conflict with the People's Republic of China (PRC) (Coker, 2015).

The United States planned and constructed its space constellation over the past half-century under the assumption that space continues to be a relatively permissive environment without a substantial human threat. However, frequent "reversible" attacks on U.S. satellites by Russia and the PRC provide clear evidence that space is now a contested environment. The PRC and Russia have also tested nonreversible capabilities such as anti-satellite missiles and grappling satellites (Hines, 2021). China activities and tests demonstrate the capability to affect space-based operations with very little warning during a conflict with the United States. Although the PRC may lack the will to use these capabilities absent a major conflict, U.S. reliance on space-based assets for communications and missile warning makes PRC attacks on U.S. satellites probable (Erwin, 2022; Stokes et al., 2020).

The potential for the PRC to damage U.S. space assets as part of a war or to change U.S. policy is clear, but the best ways to respond to such an attack are not as apparent. This paper will examine the costs and benefits for different ways the United States could respond to a PRC attack in space as well as potential ways to deter attacks. There are no good or easy responses to a PRC attack on U.S. satellites. However, understanding the costs and benefits of different response options will help the President and military leaders build appropriate capabilities and contingency plans, faster decision making based on the circumstances at execution.

China's Attack Methods

The Chinese government offensive space technologies over several decades and considers these developments as essential to winning the "modern" war in space. The Chinese threat to U.S. space systems fits into three main categories: kinetic, cyber, and jamming. In these categories, offensive actions and/or tactics include, but are not limited to, denial and deception, directed energy, co-orbital attacks, ground station attacks, cyber-attacks, signal jamming, and nuclear detonation. This paper discusses some of the PRC's kinetic, cyber, and jamming capabilities while acknowledging that the PRC has several other capabilities.

Since 2018, China has become a global launch leader and currently has over 400 satellites in various orbits with numerous defensive and offensive capabilities. Some of these assets have the capability to maneuver near, attack, survey, and deorbit other satellites. Recently acquired data from space tracking firms show that one such asset, the Chinese Shijian-21 satellite (satellite with a robotic arm) docked with the defunct Beidou-2 G2 navigation satellite and performed a large burn, moving the spacecraft out of the GEO belt. Shijian-21 undocked from Beidou-2, leaving that spacecraft in a disposal orbit well above GEO, and has since returned to GEO. China describes the Shijian-21 as a space debris mitigation satellite but has not released details about the satellite or its planned objectives (Hitchens, 2022).

Another counter satellite capability China is developing exists in cyberspace. In the February 2022 article titled "The Urgency to Cyber-Secure Space Assets," author Chuck Brooks emphasizes that as far back as 2014, China had been hacking satellites and causing disruptions across several mission areas. One case involved the PRC hacking into the National Oceanic and Atmospheric Administration (NOAA) network causing disruptions across the globe for numerous users/countries resulting in faulty weather data. While this is not a kinetic event, and to many these attacks seem minor, cyber-attacks on satellites constellations can result in kinetic effects (GPS faults, ISR faults, C2 take over, etc.) that could potentially cause ripple effect across multiple entities and industries. Critical cyber vulnerabilities for space-based technologies include the complex nature of ground systems, long range telemetry for communication, and open protocols used for uplinks and downlinks represent (Brooks, 2022).

The Chinese satellite jamming capability poses a severe threat to space-based assets across a myriad of mission areas as well. The capability to jam Global Positioning (GPS), protected/secure communication, and ISR satellites represents a clear and present danger to U.S. and partner countries' operations across the globe. In late 2021, Gen John "Jay" Raymond testified to Congress that the U.S. must act quickly to counter the threat posed by Chinese electronic jamming and directed energy weapons (Keller, 2021). The PRC first acquired their ground-based jammers from Ukraine in the early 1990's but has since developed their own technology for deployment within their territorial borders. PRC and its defense industries are developing new technologies e such as jammers capable of targeting satellite communications over a large range of frequencies, including dedicated military communication bands (OSD, 2020). If utilized, Chinese jamming technologies could render U.S. space assets deaf or blind.

United States Policy Review Regarding Attacks of On-orbit Capability

The U.S. government recognizes the threat to its space capabilities and has issued several national policy and guidance documents related to space, defense, and cybersecurity over the past six years to make its space capabilities more resilient. In order to better understand the utility of existing policy in support of protecting on-orbit capability in a China-United States conflict in the Pacific Theater, we used a variation of a Pugh Matrix to assess the policies across different administrations for deterrent value, asymmetry, and declarative statement. Deterrent value measures the policy's ability to deter potential adversaries from engaging U.S. space capabilities. Asymmetry measures if the policy defines symmetrical response or allows for non-in-kind response(s). Clarity refers to policy language in the ability of allies or potential adversaries to understand the U.S. policy and any retaliatory response(s). Consistency measures how stable the U.S. message is over time.

In using the Pugh Matrix, each section was measured using --, -, 0, +, ++ scale ranging from" addresses the opposite of the value in the policy" to "unambiguously addresses the value in the policy". The neutral value, 0, means the policy does not clearly address the section in any manner. The vertical total indicates how well the individual policy meets all measurement criteria and horizontal total is a representation of the criteria across all policies.

The policies evaluated are listed in the table below. Since the paper is at the unclassified level, all reviews but the 2022 National Defense Strategy are derived from the unclassified publications but in tandem with each of the referenced documents. Since there is no associated unclassified coverage of the 2022 National Defense Strategy, the strategy was assessed only using unclassified information published in the classified document while using generalizations of this material.

Policy	Deterrent Value	Asymmetry	Declarative	Total
Defense Space Strategy (2020)	+	+	+	++
United States Space Priorities Framework (2021)	-	0	-	--
Interim National Security Strategy (2021)	-	-	--	---
National Defense Strategy (2022)	+	+	-	+
Total	0	+	---	////////

Based on the policy review, U.S. national cyberspace, space, security and defense policies/strategies provide the construct for effective space deterrence. But to effectively use deterrence, any adversary needs enough information to understand United States resolve while allowing some level of ambiguity to leave a level of uncertainty on the specific avenue of United States action, especially if the response does not warrant nuclear options. In most cases, it is demonstration of capability and inherent ambiguities of capabilities the adversary suspects but lacks information, which feed into an adversary's decision calculus.

Asymmetry ties into declaration in it ensures adversaries and allies understand what actions the United States will take given a certain action by an adversary. Most of the policies do not address avenues of retaliation, but as indicated previously, ambiguity is not necessarily a bad thing. If an adversary knows you are locked into manner of response, it allows them to predict and potentially counteract United States action. Declarative policy is the most useful result of the Pugh Model assessment. Understanding what the United States views as an adverse action and the scale of retaliation is useful for understanding how the United States can impose costs or deny benefits of adversary action.

Evaluating Three U.S. Response Options

Response and Theory of Victory

The U.S. has the option to conduct a kinetic or non-kinetic attack on a PRC satellite or space system in response to a PRC attack on a U.S. satellite system. Numerous factors inform which type of space control action the United States would take. The factors examined were what other PRC military activities are taking place, is the desired space control action reversible or non-reversible, and what is the desired effect on PRC future actions. For the U.S. action to be deemed successful, further PRC offensive actions in space must be deterred or PRC military operations degraded.

Space assets enable military operations for the U.S. and PRC alike. Both forces broadly rely on space assets for non-line of sight communications and enhanced intelligence surveillance and reconnaissance (ISR) (Reilly, 2016). U.S. counter space capabilities could impact or hinder PRC space systems which enable; position, navigation, and timing (PNT), imagery intelligence (IMINT), signals intelligence (SIGINT), communication, and surveillance. Depending on the type of satellite and its mission, it will be in either, low earth orbit (LEO), medium earth orbit (MEO), highly elliptical orbit (HEO) or geostationary orbit (GEO). This paper addresses four U.S. counter space options: anti-satellite weapon (ASAT), counter communications system, high-power radio noise jammers, and lasers (Heginbotham et al., 2015).

A PRC attack on a U.S. satellite would likely be done in support of an on-going or imminent military action (Dodge, 2004). A PRC military action would most likely take place in the South China Sea (SCS) or against Taiwan. PRC requires IMINT, PNT, and SIGINT capabilities for successful operations in either area, but is more heavily reliant on communications satellites in a SCS scenario for the command and control of military forces due to geography (Heginbotham et al., 2015).

The United States has a range of reversible (temporary capability degradation) and non-reversible (permanent damage) ways to attack a PRC satellite. The U.S. could employ an SM-3IIa or THAAD missile as an ASAT to destroy a PRC satellite in LEO. The second counter space option utilizes a counter communication system to jam PRC satellite communications, which has a temporary effect. The third option utilizes terrestrial based radio transmitters to jam PRC satellite receivers with radio noise. The last option utilizes lasers to disrupt optical or imagery sensors; essentially blinding the satellite and preventing it from observing and collecting intelligence. Depending on the type of laser and how long the satellites "eye" was open, this effect can be either permanent or temporary (Heginbotham et al., 2015).

Benefits

A U.S. attack on PRC satellites that deters future attacks or degrades their military capability benefits the U.S. and its partners and allies. An action by the U.S. would likely deter a future PRC action in space as the real cost is higher to the PRC. As the U.S. has a more diverse and larger inventory of space assets, any space control action the U.S. conducts will likely affect a higher percentage of the PRC space constellation and PRC military capabilities that rely on space assets (Heginbotham et al., 2015). For example, if PRC cannot utilize space assets to enable the detection and tracking of U.S. maritime forces in the Pacific, then it becomes much harder to find and strike U.S. ships. If the PRC cannot hold U.S. forces at risk, the joint force possesses freedom of maneuver to support operations in the SCS or in a Taiwan scenario. (Fivelstad, & Lai, 2018)

Costs/Risks

The level of risk for a U.S. physical response in space depends on the type of response. A reversible or non-permanent effect carries less risk than a permanent effect in terms of affecting space but may carry more risk of not having the intended effect. Meaning, if the action has no real impact on the PRC, then it may not deter future PRC actions. The use of an ASAT against a PRC satellite could incur the most risk in space due to two factors: the potential for an increase in space debris, which could impact other satellites or space systems and the potential PRC retaliation could be much greater than expected (Krepon et al., 2007). On the other hand, an action in space with a permanent effect may be the best deterrence providing the lowest amount of risk to a mission.

Conditions when this is the best response:

Any acknowledged U.S. action in space that affects PRC satellites should only be considered for use in conflict and crisis. Actions that cause permanent damage should be limited to non-debris causing activities. Operations that cause irreversible damage should be a last resort against targets that primarily support military activities and substantially constrain or threating U.S. operations. A non-permanent effect such as jamming communications, could be employed in a much broader range of circumstances, including during a crisis to help prevent conflict by demonstrating resolve and capability.

Force on Force Response

A traditional, force-on-force, response to China risks large economic and political impacts, and escalation to nuclear war. A large-scale war would also have calamitous effects on world trade (Rovner, 2017). If it can be contained to non-nuclear warfare, the US has some strategic advantages, especially in naval and air combat, but China is rapidly modernizing their forces (Rovner, 2017).

According to the Office of the Secretary of Defense (OSD), China seeks "to become a "world-class" military by the end of 2049," with capabilities to compete with, and in places exceed, the United States. They have marshaled the resources and political will to do accomplish this objective and have made extraordinary gains in both quality and quantity of developed technology and in modernizing their army's operations (Office of the Secretary of Defense (OSD), 2020).

China has surpassed the U.S. in shipbuilding and has longer-range, ballistic missiles, with over 350 ships and submarines compared to 293 in the U.S. fleet. PRC has "more than 1,250 ground-based ballistic missiles (GLBMs) and ground-launched cruise missiles (GLCMs) with ranges between 500 and 5,500 kilometers" compared to U.S. GLBMs "with a range of 70 to 300 kilometers and no GLCMs" (OSD, 2020). China also has one of the world's most formidable air defense systems with its long-range-surface-to-air systems (OSD, 2020).

Response and Theory of Victory

In simplistic terms, despite having less vessels, the U.S. is a sea power, and China is a land power (Coker, 2015; Rovner, 2017). The US is also superior in air power, but China is modernizing rapidly in this area. The "straightforward" path to victory in China is assumed to be absorbing the initial Chinese strike (e.g., not being the initial aggressor), then degrading Chinese anti-access, area denial (A2AD) capabilities to the point that U.S. air and naval supremacy can be established (Gompert et al., 2016). The U.S. currently has naval superiority and would hold an advantage by blocking the main sea routes that China may need to maneuver troops and sustain supply lines (Coker, 2015). This scenario becomes less likely as China modernizes its defenses and A2AD capabilities.

Benefits

In addition to air and naval superiority, the geography favors the US for maintaining trade in a protracted war. A major war in the Western Pacific would lead to a huge disruption in trade, which would have a much greater detrimental effect on the Chinese than the US. The US would mostly lose its bilateral trade with China, but China could lose the vast majority of trade with its neighbors, causing a huge negative effect on its economy. Decreased trade could reduce Chinese GDP by 25%-35% (Gompert et al., 2016).

The Chinese Communist Party (CCP) retains legitimacy by providing economic security and stoking patriotic sentiment in among their middle class. If these factors are degraded by a prolonged battle, the stability of the party CCP could be threatened. Separatist movements in Tibet, Taiwan, etc., could also be emboldened if the Chinese army is preoccupied in a major war.

If the war can be constrained to traditional land-sea-air battles (a large assumption), it would prevent escalation to nuclear war and further escalation of attacks on space assets, both of which could have devastating consequences (Coker, 2015). China has a no-first-use policy for deploying nuclear weapons (Rovner, 2017); if the US can trust this policy and give credible indications that they are not considering a nuclear offensive themselves, the battle would be constrained to conventional weapons.

Costs/Risks

China would have advantages in a land battle fought in their territory. They could also seize the initiative with a first strike that degrades U.S. military infrastructure. Other major risks include economic and political disruptions, China's modernizing capabilities, and potential escalation to nuclear or further space-based attacks.

If American doctrine is to not be the initial aggressor in a war with China, a precision strike by China could cripple U.S. military communications, guidance and control, and other infrastructure (Rovner, 2017). This could lead to a new generation "informatized" war, where the US has little experience and China would have seized the initiative (Rovner, 2017). This could reduce the odds of victory compared to the assumed path to victory.

Although China would suffer more from trade interruptions, the loss of bilateral US-China trade could still reduce U.S. GDP by 5%-10% in absolute terms (Gompert et al., 2016). The US also already has a divided and dysfunctional political system. Response to a protracted war could further divide them, as the costs of war mount (Gompert et al., 2016). Political pressure and nationalism could also pressure politicians to escalate to nuclear war (Rovner, 2017). East Asian states, of all third parties, have the most to lose. They would suffer with either a dominant or unstable China. Their best-case outcome would be a quick U.S. victory with a diplomatic settlement that leaves China functional (Gompert et al., 2016).

Strategically, massing troops in East Asia for a traditional war with the PRC would leave the US exposed in other areas of the world where the US has smaller, ongoing missions (Gompert et al., 2016). China is rapidly developing precision guided missile capabilities and could sink increasingly vulnerable U.S. aircraft carriers (Coker, 2015). China could use its bases and allies in the Middle East and Central Asia to block narrow inlets and canals to counteract some U.S. naval power. (Coker, 2015).

A large kinetic war may not be constrained to air-land-sea. It may also bleed into space, as so many location and guidance capabilities rely on satellites. Because space assets are so fragile and invaluable to the global economy, even a limited engagement in space could massively degrade the U.S. economy and ongoing military operations.

Conditions when this is the Best Response

The force-on-force response will work best while the US still has clear naval and air superiority, if it can be assumed that China will not escalate to nuclear war, and if homeland defense against ICBMs can be guaranteed. With time, China will modernize forces to the point that naval and air superiority cannot be guaranteed. Especially with a space-based opening salvo that degrades missile defense, homeland defense against ICBMs will also be put at risk.

Conduct Significant Cyber Attacks Against PRC Assets

Response and Theory of Victory

Responding to an attack on U.S. satellites with cyber-attacks against the PRC's critical infrastructure has the potential to deter further attacks through punishment in a manner the international community would accept as proportional. Additionally, cyber-attacks could hinder the PRC's ability to physically attack the United States or other countries in the region. Success requires the attacks to inflict sufficient damage on the PRC to negate any advantages gained by attacking U.S. satellites or ground stations without overshadowing PRC aggression.

The United States could use intrusive or unintrusive cyber techniques to punish the PRC for attacking satellites. Intrusive attacks require gaining access to the targeted network and then manipulating data on the network or instructing physical equipment to operate differently.

Manipulation activities generally require privileged access and have a very wide range of impacts from temporary service disruption to encrypting or corrupting data to destroying physical equipment such as power plant generators (Greenberg, 2019). Unintrusive attacks, like a denial of service operations, are generally easier to execute but have less anonymity and a narrower range of impacts. (Forrest Hare and William Diehl 2020) So long as the cyber-attack aims to achieve an impact on PRC systems similar to PRC attacks on U.S. satellites, there is little need for anonymity. Furthermore, attributable intrusive or unintrusive attacks offer the benefit of clearly communicating to the PRC and the world that there are substantial costs to attacking U.S. satellites.

The United States should prioritize attacks against seaport infrastructure, cargo ships, fuel distribution, and communications nodes because these areas all have substantial connections to PRC military capabilities as well as commercial entities, which makes them comparable to U.S. satellites. Seaport infrastructure and ships that could support an amphibious assault of Taiwan, such as roll-on/roll-off ships, should be the top priority. The PRC requires these capabilities for its economy and any effort to seize Taiwan. For example, PLC military exercises since 2019 have used civilian ferries for amphibious assault operations making them a legitimate target for military cyber operations (Yeo, 2021).

Benefits

Cyber-attacks that effectively degrade the PRC's ability to invade Taiwan and damage its economy provide an adequate response to PRC attacks on U.S. satellites. The flexibility of cyber-attacks to be attributable or non-attributable as well as permanent or temporary allows the United States to appropriately tailor the specific operation to the international context and PRC aggression. Most importantly, this response option will not increase space debris like a kinetic attack against PRC satellites. Preventing additional space debris is a critical issue because every additional piece of space debris increases the probability of a "potentially catastrophic accumulation of debris in low-earth orbit," often referred to as the Kessler Syndrome (Drmola & Hubik, 2018). Such an accumulation would affect the usability of space both during and after the conflict regardless of who wins.

While non-kinetic attacks against satellites or ground control stations may not directly cause space debris, they increase the potential for accidents that could result in more space debris. For example, disrupting a ground station may prevent controllers from seeing or preventing a collision. Separately, jamming a satellite might pressure satellite controllers to rapidly shift orbits that could also lead to accidents. Regardless of the type of attack, each space attack increases the normalization of conflict in space that endangers the human race's ability to benefit from the unique capabilities space offers, especially in low-earth orbit.

Costs/Risks

The two critical risks for cyber-attacks are the introduction of dangerous cyber weapons into the world that others can use and the potential for the PRC to escalate and attack U.S. civilian infrastructure. Attempting to remain proportional and clear communication that such attacks would escalate the U.S. response should minimize this risk though the risk remains relatively significant.

Conditions when this is the best response:

Overall, the costs and benefits of this option suggest it is a strong option in most cases because it helps maintain the norm of avoiding warfare in space, is scalable, and could be combined with far more aggressive measures if the situation warrants. However, if critical U.S.

infrastructure lacks sufficient cybersecurity measures then the ease of attacking U.S. critical infrastructure may encourage a parallel PRC response with drastic outcomes.

Conclusion & Policy Recommendations

The three response options discussed, and several others considered all carry substantial risks. The best option depends on the circumstances. Assuming the appropriate cyber capabilities are ready, a cyber response offers the best balance of risk and reward in most circumstances. The cyber response can cause substantial punishment to the PRC without alienating the international community, significantly escalating the conflict, or significantly reducing humanity's ability to use space. However, there is no good way to respond to a PRC attack on U.S. satellites. A cyber response may have minimal impact or expand well beyond the intended target. Therefore, the United States should expend substantial effort to develop and implement policies that deter attacks on space assets while reducing the risk of faulty or negative response options.

Establishing an international framework for space that mirrors maritime law and a clear, declarative policy for responding to space attacks offer two concrete ways to deter attacks on U.S. satellites by the PRC or other hostile entities. Satellites on orbit are similar in operation to maritime resources: objects in the domain are considered sovereign assets, most of the operating area of the domain is not owned by any country, there is need for traffic management to prevent accidental collisions, there is an inherent need to establish legal standards, and the owning nation needs to protect their citizens' rights. Developing a strategy that mirrors maritime law will establish some of the requirements for international standards as Space is increasingly a warfighting domain. However, a more declarative policy with respect to China for the scope in this paper is suggested.

It is understood China is watching the events in Ukraine with an eye to how the United States responses to another nuclear power's declarative statements. While China has publicly declared a "no first use nuclear policy, they have also acknowledged they maintain a nuclear arsenal to prevent nuclear coercion; a scenario NATO finds itself limited to future actions in the Ukraine Crisis. It is possible China may use a similar statement if they view the United States and Pacific allies as having an insurmountable conventional advantage. If the United States does not have a declarative policy fully understood by all, this is more likely in a Taiwan or INDOPACOM theater scenario.

But a need for a declarative policy extends beyond denying nuclear coercion. While ambiguity may lead to adversary indecision, having a clear message of what the United States will not accept could likewise lead to an adversary making a decision we want them to make. Currently the United States is ambiguous on cyber actions and where there is unambiguity, it is complicated by an ability to attribute activity. For Space, policy in clear the United States will retaliate at a time and place of our choosing, it does not clearly indicate the level of retaliation—in kind or asymmetrical response (Biden, 2020).

Declarative policy can have drawbacks. Stating "redlines" and showing resolve could escalate a situation unnecessarily if an adversary feels it has no recourse than mitigate the worst-case scenario. There is also a possibility an adversary may take declarative policy as absolute, leading to a situation which contributed to the invasion of South Korea. Much as the proverbial genies wish, understanding the full implications of what is stated and how it could be perceived is critical to effective declarative policy.

So recommended language for declarative policies would include stating that while the United States maintains nuclear weapons for strategic deterrence, the United States will consider any attempt of nuclear coercion as a direct threat to the United States. In addition, the United States will use all means to protect the United States from existential threats, including weapons of mass effect. Declaring actions in space which threaten United States communications and infrastructure as threats to the essence of United States way of life would add to an adversary's decision calculus.

The United States and every other country should expend substantial effort to deter conflict in space because no one wins a space war.

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