Integration of Space Weapons in the Joint Force

Re-Shaping Defense Space Strategy through 2030: Shifting from Space Security to Space Superiority

CAPSTONE PAPER

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Price School of Public Policy
Viterbi School of Engineering
University Of Southern California
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The relationship between the United States and China is a complex and ever-changing dynamic, characterized by recent increases in tension. Despite this, the two nations remain closely intertwined across various spheres, including security issues and their economies. Managing this dynamic requires a nuanced understanding of the interplay between these different areas, including the often-misunderstood topic of China's rapid space weaponization and its significant impact on current and future U.S. space and terrestrial operations. As this domain becomes increasingly contested, it is essential for policymakers to fully grasp the complexity of this issue and its broader implications for U.S. national security. However, there is a lack of comprehensive analytical coverage on the limitations of current U.S. defense space strategy vs. that of China's advancing space warfighting posture, making it all the more challenging to navigate. In this paper, we aim to shed light on this critical area of study, providing a space superiority framework for the U.S. to shift to and be prepared for the threat posed by China's weaponization of space and its implications for U.S.-China strategic competition.

From the Pacific Theater perspective, 2022 saw a successful year in China's space deterrence and warfighting weapons technological advancements. The year consisted of 64 launches, trailing only the U.S. globally with 87 (Jones, 2022). The Beidou Positioning, Navigation, and Timing (PNT) satellite constellation remains world-class. These technological milestones in the space domain compared with China's space capability developments, such as the anti-satellite demonstration in 2007, are remarkable.

In early 2023, a surveillance balloon of Chinese origin transited the United States and was subsequently shot down, capturing media attention across the country. Concerns of potential threats posed by China's high altitude surveillance balloon were broadcast to the American public. However, the Chinese balloon's surveillance capabilities are not even a small fraction of China's robust network of space-based sensors. Beyond China, the commercial space sector's remote sensing satellites are ever-present when considering all nations, posing significant challenges to standard terrestrial military operations at present, and even more so in the future. China has also demonstrated its continued pursuit of a multi-layered attack architecture from simply testing and deploying ground-based ASATs to testing advanced orbital counterspace capabilities such as the Shijian-21 satellite in geostationary orbit. During a recent test, the vehicle docked with a defunct Beidou satellite and moved it into a graveyard orbit (Jones, 2022).

The ever-present growing threat posed by China to our critical space infrastructure demonstrates space linkages to all aspects of modern life, which are at greater risk as time progresses. This scenario has never been previously experienced to such an extent in human history. This research project examines current and future space policy and technologies, their impacts on terrestrial military operations, and it presents viable strategic objectives for consideration as solutions for the shift of the U.S. space posture from one based primarily on resiliency to one focused more on space superiority through the addition of space weapons systems into the arsenal of our nation.

Problem Statement: The United States and China are seeking two different ends in space. China is pursuing a strategy of active space superiority, while the U.S. strategy pursues a less aggressive and mismatched strategy of space security. Conditions of previous U.S. conflict during the Global War on Terrorism (GWOT) saw space as an uncontested domain throughout allied combat operations. China is seeking to win the race for overmatch in space, where U.S. joint forces and allies are under persistent threat of space surveillance and targeting of U.S. and allied land, sea, and air operations. Further, critical U.S. space infrastructure is increasingly at risk due to China's growing deployments of ground and space-based counterspace capabilities. U.S. space policy and exquisite space capabilities development must advance from mere research and development projects, the lion's share of the Space Force's budget, toward a more effective posture for space superiority that pursues offensive and defensive counterspace weapons integration and space domain awareness to maintain deterrence against attack in, from, and to space.

Methodology

The methodology for this study consists of comparative analysis based upon qualitative research to examine the strategic shift in priorities that would enable the U.S. to become capable of space superiority by 2030. The risk analysis framework will evaluate the force posture of China and its pursuit of space superiority and assess the risks of action and inaction of the U.S. against responding to this threat with countermeasures and space weapons systems capable of challenging Chinese threats and achieving U.S. superiority in a future conflict in the Indo-Pacific. The analysis consists of examining publicly available Chinese strategic guidance and operational concepts for space deterrence and warfighting, which provides the context and rationale behind why the United States Department of Defense must change its strategic defense framework toward a more effective and credible space superiority strategy requiring offensive and defensive space weapons.

Summary Background

Access to and freedom of navigation in space is and has been a vital strategic national interest of the United States for decades. As the utilization of space-based systems has expanded exponentially over the past seventy years, space power has become the very linchpin of U.S. instruments of national power, particularly that of the military instrument and its ability to timely project influence and combat power in any desired place or manner. While space power has been a primary U.S. enabler of terrestrial combat operations in the air, land, and sea domains, China understands that space is the foundation for U.S. current conventional and nuclear force superiority and that U.S. space infrastructure has vulnerabilities. As a result, as Under Secretary of Defense for Policy Colin Kahl has stated that "China is doubling down on the use of space for war" (Albon, 2022, para. 3). China has shifted from its conventional land and emerging sea power focus to the rapid development, deployment, and use of offensive People's Liberation Army (PLA) space forces designed to negate America's military advantages in the Indo-Pacific and beyond.

China has competed with the U.S. consistently through its establishment of its space force in 2015 and the continual deployment of kinetic and non-kinetic space weapons systems in rapid fashion. This multi-layered attack architecture consists of a range of weapon systems that pose threats to U.S. critical space infrastructure across all segments of space operations and its terrestrial integration. In 2022, China was second in the world in number of launches, yet the leader in defense-related payloads, launching 45 payloads (see Figure 1) while the U.S. trailed with 32 (McDowell, 2023, p. 11). The strategic concept of system destruction, leveraging mobile warfare operational concepts, are the PLA military aims of this effort against the United States and its allies. As Lt. Gen. Chance Saltzman, Chief of Space Operations for the Space Force states, "The most significant challenge is the pace in which they [China] are developing all their systems, it is such a broad array of the counter-space capabilities that they are pursuing (Eurasian Times, 2021, para. 1).

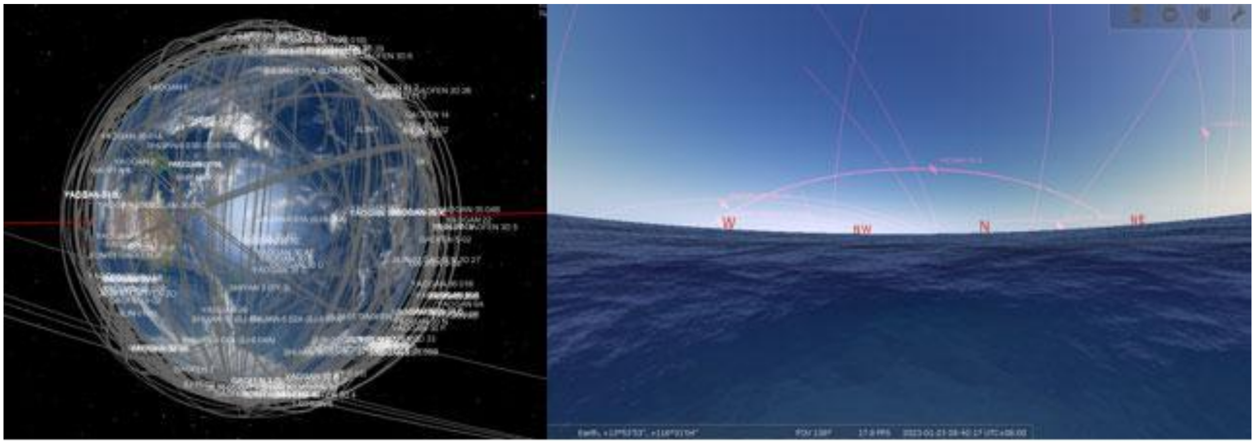

Figure 1. China’s growing military and commercial surveillance satellites provide persistent coverage (depicted in LEO and from the South China Sea)[1]

Despite the expanding threat from China within the space domain, U.S. critical space infrastructure remains vulnerable to attack. These realities hinder U.S. space domain support to theater-wide operations in the Indo-Pacific and do not address the pursuit of independent combat operations to achieve escalation dominance in space. China continually challenges space capabilities across the entire counterspace continuum. In addition, the U.S. space domain awareness capabilities across multiple orbits face growing competition with China’s sensors (Defense Intelligence Agency [DIA], 2022, p. 8), eroding an advantage in situational awareness of space operations.

These shortfalls, if not addressed in the near term, will prove decisive for the PLA’s potential success in a major conflict with the U.S. and allies pursuing similar strategies. U.S. Space Forces must be properly equipped to fight and win in space against this pacing threat. Readiness for future conflict requires the U.S. Space Force to have a multi-layered attack architecture to gain space superiority, defeat threats to U.S. and allied space assets, and

[1] TLE data accessed in Celestrak.org, visualized in Celestia and Stellarium astronomy software.

continuously provide joint and allied forces with integrated space domain effects required for future contingency readiness.

Literature Survey

International Space Law Governing Military Activities in Space

Analyzing the definition of space weapons from established international law and proposed treaties within the international community reveals great flexibility for space powers worldwide. Article IV of the Outer Space Treaty prohibits the placement of nuclear weapons or any other weapons of mass destruction in orbit around the Earth, on celestial bodies, or in outer space in any other manner (Outer Space Treaty, 1967, art. IV). The draft treaty proposed by Russia and China to prevent the placement of weapons in outer space defines a space weapon as "any outer space object or component thereof which has been produced or converted to destroy, damage or disrupt the normal functioning of objects in outer space, on the Earth's surface or in its atmosphere, or to eliminate human beings or components of the biosphere which are important to human existence, or to inflict damage on them by using any principles of physics" (PPWT, Russian Federation & People's Republic of China, 2014, p. 2). However, China and Russia's own operational doctrine and weapons deployment activities run contrary to the push for PPWT and other disarmament actions at the UN.

Chinese Strategy of Space Superiority

Since the launch of the first American satellite into orbit in 1958, satellites have become indispensable to modern life. Because they are critical to today's highly interconnected world, the degradation or destruction of space assets and the networks they enable could result in massive impacts to civilian life. In fact, GPS is now vital to nearly all forms of air, land, and sea transportation as well as the agriculture and energy sectors of the Western world. The human and economic consequences of even a temporary loss of GPS signals to these sectors could be severe. GPS and other satellite constellations have become a “center of gravity” for the military and economic power of the U.S. This reality has not gone unnoticed by China, as seen through development of the Beidou positioning, navigation, and timing (PNT) constellations in medium earth orbit (MEO) and geosynchronous earth orbit (GEO) (DIA, 2022, p. 12).

During Operation Desert Storm, China’s military leaders noted that space systems provided U.S.-led coalition forces with precision navigation and enhanced command and control across challenging terrain. These nascent advantages became more and more critical to U.S. forces during Operation Allied Force in Kosovo and later in Operation Enduring Freedom and Operation Iraqi Freedom with the advent of operational GPS aided weapons in the late 1990s. Today, the DOD’s reliance on space is central to its new warfighting concepts, including Joint All Domain Command and Control (JADC2). As such, it is no surprise that China has pursued a strategy of space superiority with the requisite space and counterspace systems intended to surpass and eventually gain military superiority over the United States.

China’s view of space warfighting. China seeks to exploit U.S. vulnerabilities in space through its unique view of deterrence and warfighting. America’s greatest strategic competitor does not share the U.S. perspective of basing deterrence solely on resilient architectures capable of absorbing hits or by merely threatening the use of terrestrial force—China intends to use force in space to coerce and prevent an enemy from intervening against its operations from the onset of conflict. This “attack to deter” concept relies on rapidly maneuvering its space forces to exploit an adversary’s weak points and achieve psychological and physical effects (Zhaoli, 2023). Toward this end, the PLA is preparing to conduct space and counterspace operations that will disrupt, preempt, and dislocate its enemies:

- Disruption. China could conduct disruption operations in a “period of tension” or combine them with “rapid and destructive” space attacks to create reversible and irreversible effects on U.S. and allied space systems (Zhaoli, 2023, p. 230). This may include pre-conflict operations, such as jamming and blinding an adversary’s intelligence satellites with lasers or high-powered microwave weapons. In a more advanced state of crisis, these lesser actions could be combined with simultaneous ASAT kinetic strikes.
- Preemption. Preemptive operations are intended to defeat an enemy before fighting has begun. China believes it is important to “create psychological fear…and have an influence on…national decision makers” to achieve its strategic objectives before a war has officially been declared (Zhaoli, 2023, p. 229). This course of action is vital to China’s “attack to deter” form of deterrence and the seizure of the initiative in conflict.
- Dislocation. If an attack to deter fails to create the desired impact and coerce U.S. leadership to take a strategic pause, China would be prepared to conduct prompt offensive space operations to dislocate U.S. and allied space power advantages by delivering “destructive strikes to the enemy [in space]…in order to fight rapidly, conclude the operation rapidly, and to withdraw from the confrontation” (Pollpeter, 2016, p. 342).

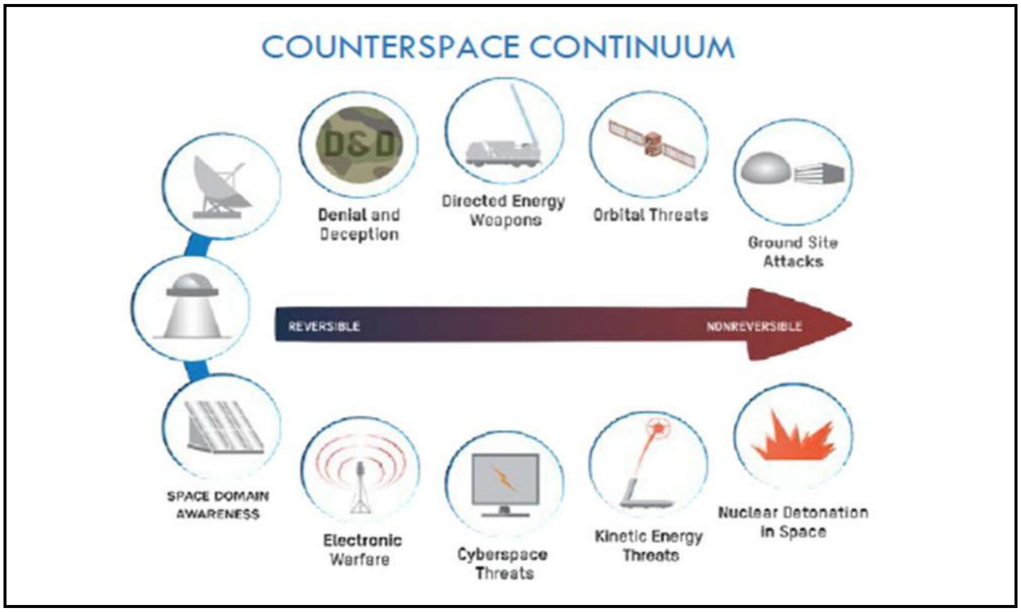

Figure 2. Counterspace Threat Continuum | Image Courtesy of Defense Intelligence Agency (DIA)

China continues to rapidly expand its operational counterspace weaponry, including its arsenal of ground-launched missiles carrying ASAT kinetic kill vehicles and space electronic warfare capabilities (Office of the Director of National Intelligence [ODNI], 2021). All these capabilities are part of China's preparations to conduct its "rapid and destructive" space warfare (Zhaoli, 2013, Figure 2).

As China's military space and counterspace operations continue to mature, the ability to rapidly maneuver across orbits and even out to the moon—referred to as cis-lunar space—will become increasingly threatening and costly to U.S. security interests. The Department of Defense must address its strategic requirement for offensive, defensive, and maneuver capabilities and innovate previous methods of acquisitions to better posture for emerging space domain threats. This effort will require the Space Force to field new space vehicles with advanced propulsion technologies. The United States and its allies must keep pace with China's pursuit of a rapidly maneuvering force. This situation also drives increased needs for advanced space domain awareness to keep track of space vehicles that no longer simply follow steady orbits.

United States Current Strategy of Space Security and Strategic Restraint on Space Weapons

Space security is focused primarily upon the preservation of the space environment and not the protection or defense of the nation's space infrastructure and national interests in the space domain (Space Security Index [SSI], 2022). This strategy focuses on the mitigation of orbital debris as the primary mission with the pursuit of norms of responsible behavior in space operations applied by all space-faring states (SSI, 2022). Evidence of this includes the *United States Space Priorities Framework* further codified in the updated 2022 DOD Space Policy.

The *United States Space Priorities Framework* provides an overview of U.S. national security space capabilities, the space domain itself, and the strategic objectives from which the Department of Defense policy and posture will be shaped to address space security matters in the future. The framework views space and counterspace capabilities correctly as a threat to military forces worldwide. The framework argues for "bolstering space mission assurance" through a "resilient national security space posture" capable of absorbing, not preventing attacks across the counterspace spectrum (United States Space Priorities Framework [USSPF], 2021, p. 6). This concept views resiliency as a means for deterrence and strategic stability and a demonstration of leadership within the framework of international norms of "U.S. national security space operations will continue to comply with applicable international law and demonstrate leadership in both the responsible use of space and stewardship of the space environment" (USSPF, 2021, p. 6). One such responsible behavior is the focus on the sustainability of the space environment through the mitigation, tracking, and remediation of orbital debris. This objective has become a major part of the updated DOD Space Policy in 2022.While sustainability and responsible behavior are important factors to be influenced by the United States, such a strategy fails to address the main threat facing U.S. critical space infrastructure—the threat of attack by China's ground and space-based weapons systems.

Despite this reality, the 2022 DOD Space Policy continues the focus on responsible behavior and strengthening the "safety, security, stability, sustainability, and accessibility of the space domain" itself and does next to nothing with respect to addressing the threat of kinetic and non-kinetic strikes against U.S. and allied space assets (Department of Defense [DOD], 2022, p. 3). This policy for all DOD space operations focuses on space security over space warfighting. Guidance in the document emphasizes "protect and defend," "defensive" capabilities and pursuit of norms of responsible behavior as the directed way ahead (DOD, 2022). Finally, resilient architectures, reconstitution, and other passive means are directed as ways for denial of adversary attacks upon U.S. critical space infrastructure. Instead of space superiority based on overmatch in space, an approach of strategic restraint is in place with regard to offensive weapons, especially kinetic systems.

Strategic restraint is one of the main policy positions taken by the United States in the 1990s. To its proponents, this position has been the baseline U.S. strategy for space force design and operating concepts. Regardless of the actions of potential or active adversaries in space weapons development and deployment, it was in the nation's best interest to rely on the existence of mutual vulnerability rather than pursue a posture of space superiority. Rather than acquiring offensive and defensive systems, the proponents of strategic restraint argue for diplomatic actions, such as the advocacy of norms of responsible behavior and arms control agreements.

Background on the Concept of Resilience

Resilience is a concept derived from a taxonomy document released by the Office of the Secretary of Defense's space policy office in 2016 and codified in the Defense Space Strategy of 2020. In the taxonomy, resilience is defined as "the ability of an architecture to support the functions necessary for mission success with higher probability, shorter periods of reduced capability, and across a wider range of scenarios, conditions, and threats, in spite of hostile action or adverse conditions" (DOD, 2015, p. 3). More plainly, it means that the satellite systems of the future are to be designed in such a way as to potentially create targeting dilemmas for adversary nations and continue to provide the space-based enabling effects to terrestrial warfighters (Figure 3). This ability to support terrestrial activities despite degraded capabilities has led to the development and prioritization of proliferated satellite constellation designs in Low Earth Orbit (LEO) for numerous mission sets including satellite communications and missile warning/tracking.

Figure 3. Proliferated LEO Concept (Source: DARPA)

While resilience is the overarching goal of operations to address the present and growing vulnerability of critical space architecture, there have been fewer discussions on passive and active defensive measures for critical satellite constellations. These activities can include maneuvering away from impending threats, providing warning to operators of threats, or leveraging primarily reversible means to interrupt or minimize a kill chain. This type of design indicates an assumption that attacks upon U.S. and allied space systems will likely continue to be limited in scope and primarily of a reversible nature. This assumption is one that should not be taken as fact given the rapid development and deployment of kinetic strike options within China's arsenal.

Ends to Pursue for a Space Superiority-Based Strategy

Given the threat environment in the foreseeable future, space superiority will be a requirement during future joint or combined conflicts. To achieve space superiority, Congress must levy sufficient resources to create a U.S. Space Force capable of space superiority during conflict. To effectively deter and counter escalatory behavior in the space domain and expand its ability to protect its interests across all domains, the U.S. must pursue the following strategic priorities:

<u>Strategy Priority 1</u>: Changing the United States Space Strategy's focus should shift from a passive space security posture of absorbing attacks and resiliency alone, to a posture including resilience and space weapons systems capable of achieving space superiority against a peer competitor like China.

<u>Strategy Priority 2</u>: Negate the first-strike kinetic capability imbalance through integration of novel technologies to create strategic surprise: To deny and deter the use of ground-based, first-strike ASAT capabilities, the U.S. must leverage its technological knowledge and past experiences to deploy its own kinetic offensive and defensive capabilities in the near term. With limited development in areas for deterrence, competing powers may continue to bolster an end state of military advantage in space. As both space-based ISR networks and counterspace capabilities continue to proliferate, novel technology development becomes an effective negation means.

***Strategy Priority 3*: Rapidly field agile and responsive orbital warfare systems across multiple orbital regimes to ensure space domain awareness, active defense of critical space infrastructure, and protection of terrestrial forces during conflict from space to ground capabilities.**

Recommendations

Employment of weapons in space would impact all levels of global geopolitics, requiring deft political methods and techniques to ensure stability of the domain. The balance between strategic deterrence and conflict readiness is an additional consideration. The U.S. commercial space industry has the potential to assist in both areas. The recommendations highlight where a Joint Force targeting and fires proposal for mitigating negative domain effects from space weapons, potentially enhancing international geopolitical assurances, and where responsive space and U.S. industry may assist with deterrence and readiness.

STOW-CB Method: A Concept for Joint Force Space Weapons Integration

Given the rapid progression in space weapons deployment by China and the increasing risk toward U.S. critical space infrastructure and interests in space, space superiority must be pursued and U.S. space weapons systems must be deployed and integrated into joint warfighting doctrines and plans. STOW-CB, is one such option. The *STOW-CB* (Space Domain Target, Operational, and Weaponeering Assessment – Collateral and Battle Damage Estimate) *Method* is a proposed method for adding a rapid space domain targeting concept into the traditional terrestrial kinetic joint targeting and fires doctrine for the use of weapons in space.

Conditions of a conflict involving weapons in the space domain would be complex and challenging. Several algorithm inputs may include satellite coverage windows, the electromagnetic spectrum, satellite payload capabilities assessments, civilian dependencies, and support requirements of terrestrial air, ground, and maritime domain commanders. Conflict within the space domain would thus overlap stakeholders across the allies, civilian sectors, and military commanders from the tactical to the most strategic levels. As such, a targeting method applied to the space domain must rapidly assess dynamic desired effects, while also supporting complex mitigation strategies. The *STOW-CB Method* attempts to set conditions for the operational use of weapons in space, for the pursuit of space superiority through evaluation assessments, and estimates that significantly exceed decision pace of standard target nomination procedures outlined in the NATO Standard Allied Joint Doctrine for Targeting (AJP-3.9, 2021).

The proposed algorithm of the *STOW-CB Method* (see Figure 4) is a simplified concept visualization of basic required inputs, absent the additional detailed planning and analysis required to ensure the combat effectiveness of space warfighting operations.

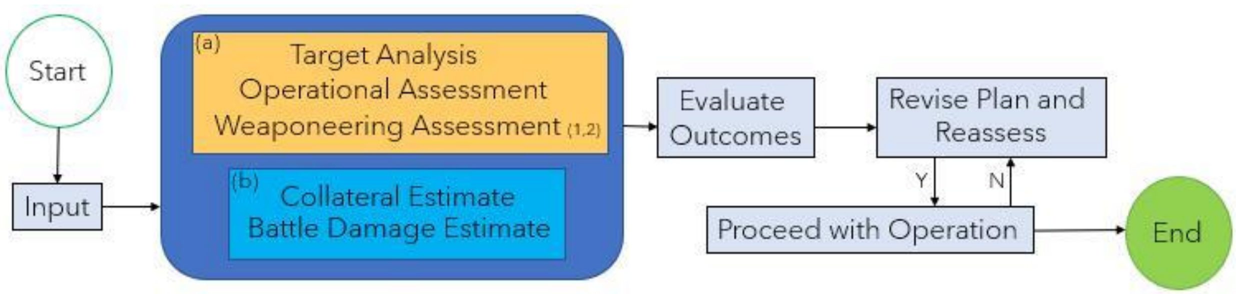

Figure 4. Proposed STOW-CB Method Concept Algorithm

Input group (a) of the *STOW-CB Method* algorithm requires space domain adaptations of target and weaponeering definitions as delineated in Joint Chiefs of Staff Publication 3-60. The Small SAR Technology Experimental Project (S-STEP) mission (see Figure 5) applied as a notional space domain target case study highlights the required *STOW-CB Method* group (a) inputs, where analysis of bus-payload structure itself = *Target analysis*, and the satellite constellation X-band synthetic aperture radar (SAR) imaging capability = *Operational Assessment*. The Weaponeering Assessment group (a) input would require (1) desired duration of effect from the relevant ground, air, maritime, or space domain commander, and (2) a probability of effects assessment to negate the *Operational Assessment* input value.

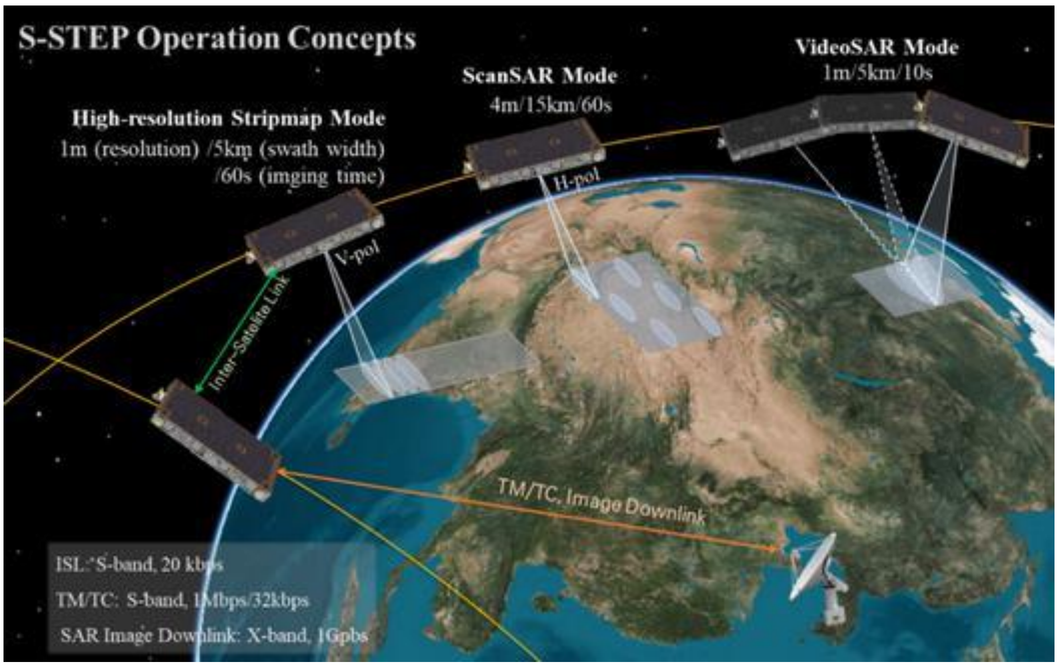

Figure 5. Kwon et al. S-STEP depiction as notional *STOW-CB Method* input group (a) *Target Analysis* and *Operational Assessment*

Input group (b) of the *STOW-CB Method* algorithm requires adaptations of *Collateral* and *Battle Damage Estimate* definitions as delineated in Combined Joint Chiefs of Staff Instruction 3162.02, Methodology for Combat Assessment (2019). Collateral Damage Estimate thresholds for the space domain are dependent upon input group (a) *Weaponeering Assessment* effects, which may impact numerous stakeholders within the space domain and require further planning assessments depending on the orbital types and target sets involved. Broadly interpreted, a space domain *Collateral Estimate* value may define the desired effect as either reversible or nonreversible and the likelihood of damage to neutral or allied satellites that are not the intended target of a weapons exchange. *Battle Damage Estimate* inputs would consist of space domain awareness (SDA) sensor planning, estimating effects against the intended target, and operational degradation within a calculated timeframe of weapons engagement.

If the evaluated outcomes can meet mission objectives from input group (a), while also achieving acceptable threshold outputs for *Collateral Estimate* input group (b), the operation will likely be recommended to proceed without further revision required.

Responsive Space and Warfighting Focus

If the nation continues its current trajectory of policy constraints on the deployment of on-orbit space weapons in competition, an alternate approach offered is to develop a fleet of response space vehicles mated with space weapons systems, ready to rapidly respond to adversary space-based threats and enabling targeting architecture during crisis or conflict.

Prior to this decade, this concept would have been untenable. U.S. small launch (less than 8,000 lbs to LEO) was costly, lacked maturity, and suffered from schedule delays and reliability concerns. Commercial satellite manufacturing averaged three years with Air Force geostationary satellites averaging closer to seven years to deliver (Henry, 2016). Commanders would not have the confidence that urgent national security priorities and operational needs could be met on tactical timelines putting the mission and forces at extreme risk. Indications and warnings of conflict may come with little or short notice, further tightening launch timelines required to gain positional advantage in the space domain.

Industry is quickly evolving to meet the demand, with companies such as Rocket Labs, Relativity, ULS, Northrup Grumman, Astra, SpaceX, Firefly, Aevum, and Vector all offering significant commercial launch capability, which would be a foundational step toward tactically responsive space. Commercial provider and site diversity will be important factors in broader architecture decisions given that various space control satellites will have unique mission and launch inclination requirements. Launching close to the equator provides increased mass to orbit and deep space access. Launching at higher inclinations provides more access to higher latitudes, which is typically best achieved by ground-based systems. The U.S. Space Force is also evolving in launch responsiveness, supporting SpaceX as recently as March 2023 with two launches in just over four hours, one each from Vandenberg Space Force Base and Cape Canaveral Space Force Station (Clark, 2023).

Many challenges persist, to include the development of common interfaces, data flow processes, and ground segments required to command and control these high-priority missions at scale. New methods of transportation, storage of both rockets and sensitive payloads, and fueling techniques would be required. Current policies surrounding FAA coordination, spectrum, and environmental impacts would need to be adapted to support range priority and no-notice launch. Financial health and stability of small launch companies present risk, as seen with the recent bankruptcy filing of Virgin Orbit (Roulette, 2023). Still, the U.S. Space Force is already pushing the boundaries to better understand how to accomplish this, with preparations underway for *Victus Nox*, designed to respond in a 24-hour window. As reported by C4ISRnet, "The challenge that we have...is that from the time we are given the go, we are supposed to have that capability on orbit in 24 hours," Sejba said during the Mitchell Institute's Spacepower Security Forum in Arlington, Virginia. "That is really going to test the entire part of the system. That's going to test responsive launch, it's going to test our ability to encapsulate, stack, launch and then have it in operations with an operational crew on the receiving end of that" (Albon, 2023, para. 4).

It is recommended that the responsive launch of critical space control capabilities is best pursued as a more realistic resiliency measure than proliferated architecture alone, to enhance space superiority capabilities already in place, or as ready reserve in the event of combat losses. It is a high value proposition to have rapid launch capability that will impose additional costs on an adversary while denying them the benefit of attacking U.S. critical infrastructure in space.

Industry and Near-Term Innovations

The expansion of the commercial space market in recent years has created opportunities to create greater speed-to-need for the rapid deployment of space weapons. The 2020s have seen an increase in satellite design options, moving from large, geostationary satellites to proliferated constellations at both Low Earth Orbit (i.e., Starlink, OneWeb, Kuiper) and Medium Earth Orbit constellations, such as SES's O3b mPower constellation. As the commercial market has expanded, increasingly proliferated commercial constellations, such as Starlink's communication satellites and Maxar's imagery satellites, have proven they can play integral roles in warfare, as seen in the current Ukraine conflict. As the commercial market continues to lead in technology, the barrier to fielding on-orbit weapons potentially shifts from an average of five years to more near-term timeframes. Industry also provides additional opportunities to contribute to a space superiority posture. One concept is a Civil Reserve Air Fleet (CRAF) for space (Erwin, 2023a). A case for using this model, where commercial industry could be used to augment military space assets in time of need, similar to calling up commercial aircraft by the Air Force for air mobility logistics, , was made as early as 2012 as an opportunity to provide resiliency and backups against attacking U.S. space assets (Arnold, 2012, p. 30).

Beyond and supporting the CRAF model, industry continues to push creative space warfighting solutions, as technologies become more prevalent and affordable. A recent example of this is Redwire's plan to install "ExoAnalytic Solutions' space-tracking software on a navigation camera aboard a satellite in orbit" (Erwin, 2023c, para. 1). This would consist of moving a ground-based solution into space to allow for more immediate response times if a satellite could see a potential threat and process an avoidance maneuver on board. Instead of relying on the older Space Surveillance Network to provide timely assessment and support, a satellite would be armed with the ability to make near-real-time decisions on board and act accordingly to avoid an attack. Further adding to opportunities to increase Space Domain Awareness, Maxar applied for licensing to use their imaging satellites to observe objects in space as well as on the ground, creating a commercial service application for on-orbit Space Domain Awareness (Erwin, 2023b). These opportunities can create additional space domain awareness and defensive options by denying an adversary such as China the advantage of timely maneuver-based strikes during disruption, preemption. and even dislocation operations against the U.S.

Conclusion

Our study has proposed a foundational strategy to enable the U.S. to shift to a space superiority-based posture and evaluated the risks associated with implementing and not implementing this strategy. Several methods for effective integration of space weapons into U.S. war plans have been identified, including an operational concept that employs current targeting and fires concepts, options for increasing flexibility and force readiness through responsive space launch, and industry innovations supporting space targeting and weapons delivery concepts. Many of the considered solutions allow for an increased deterrence posture without a massive deployment and basing of weapons in space that a shift to space superiority would entail.

In the past, the U.S. defense leadership and personnel have demonstrated exceptional adaptability to dynamic operational conditions during conflicts. However, in potential future conflicts involving contested domains, windows for dynamic operational adaptations may become unachievable due to the effects of first-mover advantage within the space domain itself. Furthermore, without a well-defined and thought-out policy strategy within the space domain, all operational-level innovations are likely to be futile, as seen in previous conflicts throughout human history. Thus, it is crucial to develop a robust and comprehensive policy strategy that enables effective space domain operations supporting current requirements of readiness and deterrence in space.

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