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ÆTHER

A JOURNAL OF STRATEGIC AIRPOWER & SPACEPOWER

SPECIAL EDITION WINTER 2023

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Special Feature

Strategy

Classification and Intelligence Challenges

Deterrence

FOREWORD

General James H. Dickinson

On August 20, 2019, US Space Command was established as the 11th unified combatant command to place a singular focus on preparing US, Allied, and partner military forces to fight and win in the space domain. The command has reached an inflection point in the Third Space Age. On the occasion of the command's fourth birthday, and as we approach full operational capability, our focus must transition from establishing the command to building it for the future. To ground this effort, it is important to establish three foundational facts we have learned over the last four years of planning and conducting space operations: the space domain is unique but not special, space is now viewed as an operational domain, and space superiority will be a precondition for space operations in crisis and conflict.

Space is unique but not special. US Space Command was established with an assigned area of responsibility (AOR), from 100 kilometers above sea level to the edge of the universe, about 46 billion light years away and ever expanding. The AOR is unique in several ways. It is supraglobal, simultaneously bordering all terrestrial nations and other geographic combatant command AORs. It is astrographic, defined by its altitude above Earth's surface, rather than by the natural or human-made geographic features upon it. It is orders-of-magnitude larger than Earth, but also the least populated—currently ten humans on two space stations.

Despite these unique features, we can and must view space as not special, but like any other domain. In fact, many aspects of military operations into and within space are becoming normalized. For example, the concept of key terrain is readily applicable to space, though it will continue to evolve as technology and capabilities advance into areas like the Earth-Moon Lagrange points, exgeosynchronous space, and cislunar space.

Space is now viewed as an operational domain. The expansion of human endeavor into any new domain was historically followed by its exploitation as an operational domain. After the Soviet Union collapsed in 1991, the ensuing age of space activity was characterized by a lack of credible threats. China and Russia both now view space as a warfighting domain and have recently demonstrated their capability and intent to undertake aggressive military activities against US, Allied, and commercial space systems.

Both nations have irresponsibly tested destructive antisatellite missiles, creating unprecedented debris fields that endanger commercial satellites and that necessitated maneuvering the International Space Station. Since the beginning of its war with Ukraine, Russia has even signaled its willingness to attack "quasi-civilian infrastructure"

General James Dickinson, United States Army, is the Commander, United States Space Command.

if it is indirectly involved in military conflict. While we always seek peace and stability in space and will continue to promote norms of responsible behavior there, we must be prepared to fight for freedom of access to and action within our AOR to accomplish our mission.

Space superiority is a precondition for space operations in crisis and conflict. While space will undoubtedly remain critical to enabling Joint terrestrial operations for the foreseeable future, we can no longer assume assured access to space and freedom to operate within it. Gaining and maintaining space superiority will be a precondition for space operations in crisis and conflict. With space's critical role in enabling Joint terrestrial operations, achieving space superiority through the conduct of coordinated supraglobal space operations to overcome threats to our space architectures and assure access to space will likely see US Space Command designated the "supported" combatant command in the early phases of a terrestrial crisis or conflict.

Conversely, denying space superiority to an adversary in the early phases could influence their decision-making and limit their ability to project combat power. The absolute necessity of gaining and maintaining space superiority, and denying it to our adversaries, requires a deliberate shift in mindset and comprehensive doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy (DOTMLPF-P) review. This must be our focus as we build the Command in the Third Space Age.

This special, all-space issue of *Æther: A Journal of Strategic Airpower & Spacepower* covers vast intellectual territory and demonstrates the significant talent of professional military education across our Joint force, Allies, and partners. The authors explore space from the aspects of deterrence, acquisition, history, doctrine, policy, and technology. They hail from the Army War College, Air Command and Staff College, Air Force School of Advanced Air and Space Studies, Army School of Advanced Military Studies, the National Labs, National Intelligence University, and from within Space Command.

This issue showcases creative thinking about space from the ranks of major to lieutenant general, and the topics cover the technological, diplomatic, operational, tactical, and social contexts on space warfighting. These pioneers in thought represent a team of space warfighters prepared to outthink and outmaneuver our pacing challenge, and if necessary, dominate through the application of superior military spacepower to ensure there is never a day without space. ***Æ***

INTRODUCTION

Dear Readers,

This special space-focused issue of *Æther: A Journal of Strategic Airpower & Spacepower* stems from an 18-month US Space Command effort focusing on space educational outreach across the profession. General James H. Dickinson's Strategic Innovation Group first collected the space research topics that each Space Command joint directorate deemed as priorities for military students, faculty, and researchers across the enterprise to engage with. In spring 2022, a wide range of military universities and programs were provided this research list, with the added incentives that the command would provide coaching and academic outreach for those students throughout the year.

Nearly 40 participants signed up for the pilot exercise. Today this special issue of the journal features the top contributors selected for inclusion in this issue. Submissions represent the US Army War College, the Schriever Scholar's Program, the Air War College, and military organizations such as the Defense Intelligence Agency, the US Space Force, the US Space Command, and elsewhere. Their ranks and experience vary from field grade officers and professional military education faculty to a lieutenant general and deputy commander of a combatant command, and many in between. Faculty research and student efforts, along with individuals balancing real-world missions with their personal academic pursuits, demonstrate additional diversity of thought.

These authors and writing teams, together with an army of volunteer editors and reviewers from across the Department of Defense, worked to create this special issue devoted to space. General Dickinson's personal foreword further illustrates his prioritization of space educational outreach and development, and his vision for the future. The Space Command's academic year 2024 space research list, with eight times more topics added, is already out and moving toward a special publication in 2024 that will build upon this one. We hope you enjoy this issue and look forward to this annually. We would also like to thank the Air University Press, the *Æther* editor and staff, and the network of coaches, leaders, reviewers, and support staff that made this issue possible. Never a day without space! Never a day without space outreach! **Æ**

Ben Zweibelson & Miller Belmont
Guest Editors

Dr. Ben Zweibelson is the director of the Strategic Innovation Group, US Space Command.
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FROM THE EDITOR

Dear Reader,

Æther: A Journal of Strategic Airpower & Spacepower is privileged to publish this out-of-cycle issue in support of US Space Command and space-focused professional military education across the Department of Defense. First, I would like to offer my deepest gratitude to Miller Belmont and Ben Zweibelson for their work as guest editors of this volume. The processes of acquisition, vetting, peer review, and author revisions are a bit like the proverbial cat-herding. Their success in these endeavors over the past year is evident in the following pages.

In the issue's **Special Feature**, former Deputy Commander of US Space Command Lieutenant General John Shaw, USSF, Retired, is joined by Daniel Bourque and Marcus Shaw in a call for a new paradigm of manuever, dynamic space operations, supported by sustained space maneuver capabilities, as positional space operations are no longer tenable in the contested, congested space domain.

Shawn Willis leads our **Strategy** forum. He details China's increasing space capabilities and its cislunar plans in particular, and recommends space strategies and future force designs based on improved space domain awareness, especially in the cislunar region. In the second article in the forum, Ben Staats argues a longer view of the rise of airpower, dating back to the late eighteenth century, is analogous to the ebb and flow of the modern Space Age from the 1960s to current space weaponization efforts. In the last article in the forum, Aaron Blore urges the Space Force to redefine its mission toward achieving victory in space as opposed to pursuing a goal of responsiveness. In an analysis of the tactically responsive space program, he finds ongoing misalignment between doctrinal terms and those used in operational plans and strategy.

In the first article of the **Classification and Intelligence Challenges** forum, Chris James proposes adapting regulations and leveraging artificial intelligence (AI) and machine learning (ML) to overcome US Space Force acquisition challenges, particularly those rooted in overclassification, barriers to entry, and antiquated information systems. The second article, by Devon Brown, Danielle Ciesielki, and Duli Chand, finds that AI and ML decision support system statistical models can augment collection capabilities, data repositories, and threat analysis in support of more timely and relevant information for decisionmakers. In the third and final article in the forum, Alex Fiore outlines the threats posed by adversary orbital antisatellite (ASAT) systems. He argues the United States should acknowledge some of its own orbital ASAT capabilities for deterrence, while keeping classified its more specialized systems to preserve defensive capabilities, despite the resulting reduced effect on deterrence.

The final forum, **Deterrence**, leads with an article by Ron Gurantz acknowledging the importance of targeting terrestrial assets that support space systems. Considering the role symbolism plays in deterrence and messaging, he suggests the United States could create symbolic relationships between acts of space aggression and terrestrial targets. The issue and this forum closes with Alex Turpin's examination of deterrence theory and a study of Able Archer 83 to gain insights into a successful approach to deterrence in space that includes stratified deterrence, dissuasion deterrence, control of space, and resilience.

Thank you for taking the time to read our special space-focused issue. We are pleased to promote these military scholars' ideas and recommendations, and we appreciate your continued readership and support of the journal. ***Æ***

~The Editor

Special Feature

DYNAMIC SPACE OPERATIONS

THE NEW SUSTAINED SPACE MANEUVER IMPERATIVE

John E. Shaw
Daniel R. Bourque
Marcus Shaw

As in the battlespace on Earth, the force capable of sustaining maneuver in space will have the advantage. This maneuver, however, will require a scale previously unknown to a domain thus far dominated by Keplerian and Newtonian thought. The paradigm of positional space operations must be replaced by a paradigm of dynamic space operations, where spaceborne combat forces are no longer static and predictable.

Military history is replete with examples of combat forces employing maneuver warfare to move quickly, sidestep defenses, achieve surprise, reorient quickly in the battlespace, and hold centers of gravity at risk to achieve victory.[1] As in domains of human endeavor on Earth, the advantage in space will go to the force capable of sustaining maneuver on a scale previously unknown to a domain dominated thus far by Keplerian and Newtonian thinking.

The current paradigm of positional space operations (PSO) must naturally give way to dynamic space operations (DSO), where spaceborne combat forces are no longer static and predictable. Moreover, a dynamic and dominant force in space will only be as effective as its ability to sustain space maneuver—particularly in the face of an adversary. Only then can that force maintain initiative, achieve surprise, and outmaneuver an adversary in the space domain to achieve victory.

Lieutenant General John Shaw, USSF, Retired, served most recently as the deputy commander of US Space Command.

Colonel Daniel Bourque, USAF, Retired, is a senior engineer specialist, C3 engineering and ops, at the Aerospace Corporation.

Marcus Shaw is technical adviser to the commander, US Space Command, and technical support to US Space Force at the Aerospace Corporation.

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[1] John E. Shaw (remarks, Space Foundation Space Symposium, Colorado Springs, CO, April 16, 2023); and John E. Shaw and Kevin Chilton, "7.6 Schriever Spacepower Series: Lt Gen John E. Shaw," July 6, 2023, in *Aerospace Nation*, produced by Mitchell Institute for Aerospace Studies, podcast and YouTube presentation, 1:02, MP3 audio and video, https://mitchellaerospacepower.org/. All authors have been instrumental in the development of these emerging doctrinal and operational ideas.

The Timeless Value of Maneuver

In past warfare, the military advantage has often gone not to the larger or more powerful force but rather to the one capable of placing its forces at a position of advantage over the adversary at the right time—US Joint doctrine calls this action maneuver.[2] But space operations to date have not focused on sustained maneuver as a key capability. Rather, they have historically been characterized by Keplerian thinking. Using Kepler's laws of motion, satellites have been launched into desirable orbits to achieve the objectives of their predominantly Earth-focused missions.

While these satellites move at great velocities relative to Earth, from an orbital mechanics perspective, they are actually energy-constant and static—relatively unchanging and highly predictable. In these positional space operations, the mission of a satellite drives the selection of its "parking spot" on orbit, and the satellite's design, launch vehicle, and supporting infrastructure are tailored to the needs of attaining and maintaining this energy-constant position in an environment relatively free from human-made threats. Satellites designed for these PSOs generally carry only enough propulsion to maintain their position and perhaps conduct a handful of low-energy strategic repositionings over the expected lifetime of the satellite.

Positional space operations dominated the beginning of the Space Age, an era where space exploration and exploitation were extensions of strategic competition between the United States and the Soviet Union. In these early decades, sustained maneuver capability was technologically prohibitive. Combat in the space domain was considered a likely prelude to nuclear war as satellites were strategic assets, quickly escalating and making sustained space maneuver (SSM), or replenishment of consumables used in combat, an unlikely need.[3]

After the fall of the Soviet Union, space operations were characterized by the rapid proliferation of Earth-facing space capabilities—commercial, civil, and military—made possible by technological advancements and relative freedom from threats. These factors combined to push space-derived information and services down to individual users and tactical operations on Earth, and the lack of threats emphasized the Keplerian advantages of placing satellites in the right energy-constant orbits to achieve the best effect on Earth.

But humanity is now in a new Space Age, where access to space-enabled capability in daily life is ubiquitous, militaries are increasingly dependent on space to extend their reach and lethality, and commerce and reach are expanding beyond the geosynchronous belt with increasingly space-facing missions. Like any other domain of human endeavor, threats have emerged to challenge freedom of action in the space domain. These changes precipitated the creation of the new US Space Command and US Space

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[2] Chairman of the Joint Chiefs of Staff (CJCS), *Joint Operations*, Joint Publication (JP) 3-0 (Washington, DC: CJCS, 2022).

[3] Robin Dickey, *The Rise and Fall of Space Sanctuary in U.S. Policy*, 5-6 (El Segundo, CA: Aerospace Corporation, September 1, 2020), https://csps.aerospace.org/.

Force in 2019 and require the United States and like-minded partners to think differently about space operations.[4]

Traditional Earth-facing military missions now require space-facing, in-domain military missions to expand reach, keep watch, deter adversaries, project effects, and protect national and international interests. Keplerian "positional" thinking that treats powered movement across orbits as a rare and costly event is no longer adequate. The force capable of sustaining maneuver will gain and maintain the advantage over time; indeed, competitors such as China are already demonstrating many of the technologies required to sustain maneuver and act dynamically in space.[5]

Maneuver is a timeless principle of war and involves identifying adversary centers of gravity and vulnerabilities, sidestepping adversary strengths, complicating the enemy's calculus, fogging the enemy's battlespace picture, constantly changing friendly positions and vulnerabilities to mitigate weaknesses, and arriving at decisive points to gain the advantage and achieve objectives before reaching culmination, the "point in time and/or space when the operation can no longer maintain momentum."[6]

Sustained maneuver allows a force to maintain initiative, achieve surprise, and outmaneuver an adversary in the field not just instantaneously but also over the course of a campaign while forestalling the costly mistake of reaching culmination before offensive or defensive objectives are achieved and ceding advantage to the adversary. Maneuver is more than just movement; it is "movement for effect" and has often been achieved and maintained through revolutions in logistics.

Napoleon famously used large-scale maneuver in his conquest of Europe, dividing his forces into independent corps capable of moving rapidly and sustaining much of their own needs before decisively converging on an objective.[7] Admiral Chester Nimitz hailed the US Navy's ability to conduct underway replenishment as its "secret weapon" in World War II, which enabled a high operations tempo and increased fleet sortie rates.[8] Aerial refueling was explored in the interwar years between World War I and World War II and perfected in the 1950s to extend the operational range, loiter time, and therefore overall capability of combat aircraft.[9]

These revolutions in combat logistics greatly improved combat capability by enabling the most dynamic portions of a force to operate flexibly to maintain initiative, achieve surprise, outmaneuver adversaries in the field, and forestall culmination. Of

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[4] US Department of Defense (DoD), "Department of Defense Establishes U.S. Space Command," press release, DoD, August 29, 2019, https://www.defense.gov/.

[5] XueAi Li, Dapeng Yang, and Hong Liu, "China's Space Robotics for On-Orbit Servicing: the State of the Art," *National Science Review* 10 (2023): 1, https://academic.oup.com/.

[6] CJCS, *Joint Planning*, JP 5-0 (Washington, DC: CJCS, 2020).

[7] Jon Chavous, "Saddles and Sabers: Napoleon Bonaparte's Contributions to Modern Warfare," *Armor* (March–June 2014).

[8] John A. Lukacs IV, "A Century of Replenishment at Sea," *Naval History Magazine* 32, no. 3 (2018), https://www.usni.org/.

[9] Erin Lasley, "Refueling through the Century," USAF Air Mobility Command, March 26, 2018, https://www.amc.af.mil/.

note, each of these advances in combat capability could be looked at through a certain lens as cost-saving measures, but to do so would miss the point. The increased combat effectiveness of the military force was—and should remain— the driver for advancements in military logistics and maneuver.

Like the castle walls, trenches, Maginot Lines, fixed logistics points, static air defenses, and hardened aircraft shelters of past conflicts, positional space operations are no longer adequate to maintain the advantage in space. The continued adherence to PSO approaches for military space capabilities will also become increasingly risky and dangerous, analogous to warships in port, or combat aircraft on the ground. Instead, dynamic space operations will be the key to success, and sustained space maneuver will enable effective and sustained DSO. Like other advancements, cost savings may be a benefit of sustained space maneuver, but enhanced combat capability is the primary driver. Combat readiness and deterrence are also greatly enhanced through robust test and training, which are not possible without the ability to replenish capability through SSM capability.

Imagine a new main battle tank is delivered from the factory with its fuel tank and magazine permanently sealed, and its projected replacement will not arrive for eight years. Every time the tank moves a meter or fires a round, its capability is incrementally yet permanently diminished with no immediate replacement. Regardless of the size of the fuel tank or magazine, commanders would be driven to continually constrain movement and fires to avoid untenable future risk. Such a system that turns every action for short-term advantage over the adversary into long-term risk of future capability loss would be unacceptable to any military commander, yet this is exactly how today's space-domain systems are built and delivered to combatant commanders, even those designed for dynamic space operations.

The Geosynchronous Space Situational Awareness Program (GSSAP) is one such contemporary system designed for dynamic, space-facing operations.[10] GSSAP missions require the spacecraft to maneuver around the geosynchronous belt to maintain awareness on objects and activities in this congested and valuable Earth-facing orbit. While GSSAP is designed to maneuver routinely, like the imaginary unrefuellable main battle tank, it arrives on-orbit with fuel tanks sealed at the factory and programmed replacement spacecraft many years in the future.

GSSAP's limited capacity to sustain maneuver dramatically hinders an operational commander's ability and willingness to routinely maintain a position of advantage over competitors in space. The system's ability to conduct dynamic space operations is constrained by the risk of future mission failure if the limited consumable of fuel is not mission planned and heavily managed across the projected lifetime of the spacecraft. Immediate maneuver constrained by significant future risk is a poor and myopic way to compete in the emerging age of DSOs.

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10. "Geosynchronous Space Situational Awareness Program," US Space Force, October 2020, https://www.spaceforce.mil/.

As it is in other domains, the advantage in space will go to the force able to fully utilize maneuver to maintain initiative, achieve surprise, outmaneuver an adversary in the field, and forestall culmination. The better a force is able to create and sustain maneuver over time and distance, the more capable that force will be in achieving both offensive and defensive objectives without ceding advantage to the adversary. In the terrestrial domains, otherwise stationary objects achieve movement for maneuver through engines and motors which consume fuel to provide the energy to turn them from Newton's objects at rest to objects in motion.

Likewise, otherwise static objects in orbit require routine and sometimes aggressive and continuous propulsion to provide the energy to avoid remaining stationary and predictable in a Keplerian sense. A good portion of operational satellites are already capable of maneuver in space for short durations, but they have very limited capability to sustain such maneuvers, potentially reaching culmination well before operational and strategic objectives can be met and increasing the opportunity for an adversary to seize the advantage. Sustained space maneuver is the ability to keep a space capability operating dynamically over time to continually gain and maintain advantage. The force able to achieve SSM will have a clear advantage in the space domain.

Acquisition versus Operations Cost Curves: Space Imbalance?

Resource use for weapon systems over time across domains is particularly revealing in the value—or, rather, lack thereof—the space enterprise has historically put on sustainment and maneuver. At a high level, US weapon system lifecycle costs can be broken into two major categories: 1) systems acquisition (research and development plus procurement), and 2) operating and support (sustainment, maintenance, consumables, and disposal), which includes replenishment of consumables important to maneuver such as fuel.

A historical comparison of the ratios between these two categories at the turn of the twenty-first century when positional space operations were the norm shows the great disparity between space and other domains (fig. 1). For space weapon systems, systems acquisition accounted for approximately 84 percent of lifecycle cost, while only 16 percent was dedicated to operating and support. Conversely, weapon system lifecycle costs for ships and aircraft were approximately 30 to 50 percent for systems acquisition and 50 to 70 percent for operating and support.[11]

The Keplerian nature of orbits allows PSO spacecraft to perform most of their Earth-facing missions with little operating and support costs in a benign environment, but as DSO platforms and missions increase the need for sustained space maneuver, the ratio of acquisition to operations cost should naturally shift to be more in line with weapon systems in other domains where maneuver is routine.

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[11] Gary Jones et al., "Investigation into the Ratio of Operating and Support Costs to Life-Cycle Costs for DoD Weapon Systems," *Defense Acquisition Research Journal* 21, no. 1 (2014), https://www.dau.edu/.

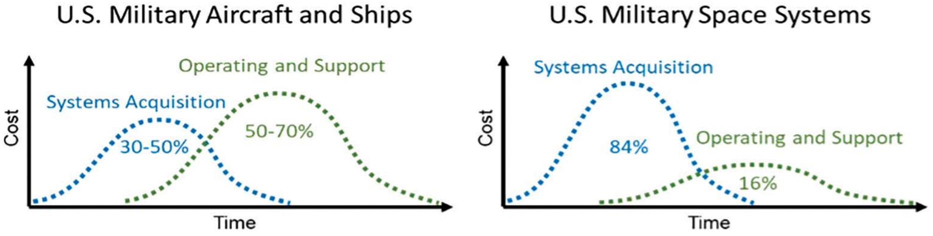

Figure 1. Lifecycle costs between acquisition and operating and support, circa 2000—when military space was focused on positional space operations[12]

Solution Vectors

Sustained space maneuver is a capability rather than a system, so there are many potential ways to achieve it. Perhaps the most obvious—and, in the near-term, most viable—approach is on-orbit servicing to replace consumables such as fuel as they are depleted. This approach might be similar to a terrestrial depot or port. Even better, on-orbit servicing could employ space maneuver itself to be more analogous to aerial refueling or underway replenishment at sea—akin to supply ships and oilers rather than ports—moving to the place of need in the space domain to keep the serviced spacecraft closer to their missions and objectives.

Another in-domain solution might come from a separate system of expendable or replenishable jetpacks. These devices would be able to connect to mission satellites and provide separate maneuver or even augmenting capabilities such as power generation that could be replaced as needed to sustain maneuver. This approach has the potential to add SSM capability to older-generation satellites that were deployed to the space domain without organic sustainable maneuver capability. These on-orbit servicing approaches also open possibilities for more agile launch operations by using smaller and more flexible launch methods to place incomplete or lighter and smaller spacecraft in the space domain to be fueled or paired with jetpacks on orbit.

More advanced propulsion technologies can also contribute to SSM, particularly ones that provide more efficient use of fuel and greater thrust-to-weight ratios. Gains in efficiency could enable significantly greater maneuver for a given propellant mass. Efficiency alone, however, is not a silver bullet for dynamic space operations. The key to sustaining DSO is the ability to remove the long-term capability risk from short-term maneuver decisions, so even spacecraft with hyperefficient propulsion systems would likely still need replenishment, just less often.

On-orbit servicing capabilities and more efficient propulsion address the challenges of DSO by removing the constraint of limited consumables over time. An alternative approach to SSM is to remove the constraint of lifetime required from a single

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[12] Jones et al., table 1, table 7.

spacecraft. Instead of replacing consumables on an individual spacecraft, the spacecraft itself would be the consumable, and an on-call replacement spacecraft would be deployed as a replacement when consumables are depleted rather than on a fixed replacement timeline.

This commoditization approach has the additional challenge of storing replacements or building them on demand, improving rapid launch capability, and disposing of depleted spacecraft, but it also opens new possibilities for surge operations to rapidly expand capability by increasing the maximum sortie rate for particularly advantageous periods of time.

A force capable of robust sustained space maneuver will likely employ a combination of all these capabilities and more. Regardless of the means, a force enabled by sustained space maneuver will enjoy numerous advantages with significant military utility:

- *Increased capability and flexibility* – provide a better range of operations, greater reach, more frequent operations, improved timelines for force movement and execution, improved posturing, and increased ambiguity for an adversary to overcome. It allows for more simultaneous dilemmas imposed on an adversary and an improved ability to strategically message through spacecraft posturing.
- *A more resilient force* – is able to respond to unplanned changes in adversary force size or effectiveness, is less susceptible to incorrect assumptions on duration of operations or adversary approach, and is more responsive to changing assumptions of probability of success.
- *Increased technical opportunities* – create more maneuverable spacecraft that are inherently more difficult to track and target, opening new avenues for protection and defense. They provide the ability to outfit spacecraft to best meet short-term mission needs and upgrade capabilities over spacecraft lifetime.
- *Greater decentralization of execution* – creates reversible decisions that can be pushed to lower levels with less risk and opportunities for more expansive and resilient use of artificial intelligence (AI) and autonomy. It decreases response times and increases the ability to improvise and pursue fleeting opportunities.
- *Improved readiness* – enables routine and robust live training with on-orbit forces without sacrificing long-term mission success. It establishes better avenues to reversibly explore new operating concepts, provides more robust testing opportunities for new systems and tactics, improves deterrence through demonstrated strength, and ensures capabilities can be quickly reconstituted to deter opportunistic third parties.

The aggregate solution set to SSM needs and challenges will likely lead to a sophisticated and versatile logistics infrastructure in the space domain, one that can benefit not only DSO platforms but traditional PSO capabilities as well. These solutions also offer many potential benefits to the civil and commercial sectors.

Space Domain Awareness Implications

Dynamic space operations will also change the nature of foundational space capabilities such as space domain awareness. Positional space operations of the past have led to the assumption that an accurate picture of the space domain can be maintained by keeping track of each object's Keplerian orbit parking spot. If these parking spots are constantly changing due to DSO, maintaining a catalog of previously observed orbital parameters for satellites is no longer adequate to address the emerging dynamic nature of space.

As in other domains, maneuvering objects must be tracked nearly continuously and in real time for the information to be of operational value. Maintaining real-time tracks of large numbers of objects over long periods of time may no longer be feasible or even desirable. Rather than maintain tracks of individual objects, space will need a more dynamic traffic management framework and a battle management framework like other domains where objects relevant to operations are quickly observed, identified, designated as threats or factors, and tracked as needed until they are no longer factors.

Impacts on Multidomain Operations

The risks of continued PSO and lack of sustainable DSO capabilities are not limited to the space domain or battlespace itself. In the era of Joint warfare and multidomain operations, maneuver in one domain can have dramatic impacts on other domains. Conversely, a lack of maneuver in one domain can create a liability for the Joint Force.

Multidomain operations rely on combinations of effects or asymmetric effects across domains with each domain maneuvering as needed to gain and maintain advantage. Any domain whose maneuver is significantly restricted will be unable to contribute its full potential to the Joint fight and will likely require significant effort in other domains to overcome its lack of effective maneuver. Even if maneuver within a conflict is possible, any domain whose short-term maneuver creates significant long-term gaps could be exploited by other strategic competitors postconflict. Sustained space maneuver is imperative to avoiding these significant risks in space and to make space forces an effective partner within the Joint Force.

Conclusion

Maneuver has historically given decisive advantages to one force over another in every domain of human endeavor and conflict, and space will be no different. Current space forces are not designed to sustain maneuver. These forces severely limit both short-term and long-term combat capability by making every maneuver decision a choice between immediate gain and long-term loss.

Military forces in space need the essential capability to continually gain and maintain decisive advantage over an adversary in both competition and conflict. This decisive advantage will allow military forces in space to maintain the initiative, achieve surprise, outmaneuver an adversary, and forestall culmination without sacrificing long-term capability. Regardless of how it is obtained, the ability to conduct dynamic space operations through sustained space maneuver will give space commanders and forces the essential advantage necessary to fulfill their role within the Joint Force and compete and prevail in future conflicts. ***Æ***

TO THE MOON

STRATEGIC COMPETITION IN THE CISLUNAR REGION

Shawn Willis

China's advancing space capabilities, particularly in the cislunar region, call for increased cislunar space domain awareness on the part of the United States. US military and civilian decisionmakers must take into account the full scope of China's cislunar plans and capabilities as the military builds space strategies and future force designs. The United States must also increase near-term investments that support more robust cislunar space domain awareness.

Approximately 20 lunar missions have been launched by multiple nations and space agencies since 2003.[1] Within the next decade, more than 100 lunar missions are expected.[2] The projected increase in cislunar activity presents security concerns for the United States and a need to increase cislunar space domain awareness (SDA).[3]

Both China and the United States are actively pursuing cislunar programs and officially promote the peaceful use of cislunar space. The US National Cislunar Science & Technology Strategy, the first interagency strategy to guide US activities in cislunar space, states, "The United States will lead the world in responsible, peaceful, and sustainable exploration and utilization of Cislunar space, including the Moon, consistent with the U.S. Space Priorities Framework."[4] Similarly, in a document submitted to the United Nations General Assembly, China states, "We should preserve space as a new frontier for

Colonel Shawn Willis, USAF, PhD, is the associate dean of the Air Force Institute of Technology's Graduate School of Engineering and Management.

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[1] Steve Parr et al., *Cislunar Security National Technical Vision* (Laurel, MD: Johns Hopkins Applied Physics Laboratory LLC, 2022), 1-1.

[2] Quilty Analytics, *Leveraging the Emerging Space Economy to Meet Critical Government Needs* (St. Petersburg, FL: Quilty Analytics, 2021), 34, https://www.quiltyanalytics.com/, qtd. in John M. Olson et al., *State of the Space Industrial Base 2021: Infrastructure & Services for Economic Growth & National Security,* ed. Peter Garretson (Washington, DC: US Department of Defense, Defense Innovation Unit, 2021), 24, https://www.diu.mil/.

[3] Parr et al., *Cislunar Security*, 1-2.

[4] Cislunar Technology Interagency Working Group, *National Cislunar Science & Technology Strategy* (Washington, DC: Executive Office of the President of the United States, National Science and Technology Council, November 2022), 2, https://www.whitehouse.gov/.

cooperation rather than a battlefield for competition and confrontation."[5]An investigation of past and current cislunar missions by China and the United States reveals not only the challenges of operating systems in cislunar space but also possible security concerns that could jeopardize the US cislunar vision if the technologies are used for nonpeaceful purposes. Since China is the United States' strongest strategic competitor in space, US decisionmakers should 1) fully consider Chinese cislunar plans and capabilities when building future strategies and force designs, and 2) continue ramping up near-term investments in cislunar space domain awareness.

Background

Cislunar Space

Cislunar space is "the region of space in the Earth-Moon system beyond GEO, including the Moon's orbit and all of the Earth-Moon Lagrange points."[6] (Of note, this article uses the terms geosynchronous orbit and geostationary orbit interchangeably, with GEO to indicate both.) This area of space presents orbital mechanics challenges not seen in near-Earth orbits since, in this region, the gravitational interaction of the spacecraft with the Moon is no longer negligible. Tracking objects in cislunar space is more difficult than tracking objects in near-Earth orbits, because in general, orbits are no longer circular or elliptical, do not repeat, are no longer contained in a single plane, and are not easy to geometrically describe.[7] As a result, very small changes in initial conditions can result in very large trajectory changes of the orbit that are difficult to predict.[8]

Consistent observations are needed to keep track of objects in cislunar orbits, but due to the extreme distances from the Earth, or even from GEO, this is challenging. Therefore, space domain awareness—the foundational knowledge and characterization of objects in space and the operational environment —in cislunar space is critical.[9] Finally, cislunar space contains five Lagrange points, where the sum of the gravitational forces from the Earth and Moon on an orbiting body result in equilibrium. This means that in the rotating frame of the Earth-Moon orbiting system, an object at one of the Lagrange points remains in the same relative position to the Earth and Moon.

Strategic Applications in Cislunar Space

Both the Moon and cislunar space have critical strategic value. The main advantages of developing lunar capabilities come from the economic potential through re-

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[5] "Document of the People's Republic of China Pursuant to UNGA Resolution 75/36 (2020)," Permanent Mission of the People's Republic of China to the UN (website), April 30, 2021, http://un.china-mission.gov.cn/.

[6] Parr et al., *Cislunar Security*, 1-2.

[7] M. J. Holzinger, C. C. Chow, and P. Garretson, *A Primer on Cislunar Space* (AFRL 2021-1271) (Wright Patterson AFB, OH: Air Force Research Laboratory, 2021), 5, https://www.afrl.af.mil/.

[8] Parr et al., *Cislunar Security*, 3-10.

[9] Chairman of the Joint Chiefs of Staff (CJCS), *Space Operations*, Joint Publication 3-14 (Washington, DC: CJCS, April 10, 2018, incorporating change 1, October 26, 2020), ix.

source extraction and from the space exploration potential, as a base from which to launch deep-space missions. At the same time, cislunar space has current and future national security applications.[10] China has indicated a long-term goal for economic dominance of cislunar space.[11] To that end, China is already using a halo orbit around the Earth-Moon L2 Lagrange point to communicate with the far side of the Moon.

Future uses of the cislunar region include military satellites in orbit at the Lagrange points used to monitor and possibly control access between the Earth and the Moon. Because of the low fuel requirements, a system of SDA satellites and dual-use satellites could interfere with another country's injection of satellites at the Lagrange points, preventing them from establishing transfer station facilities.

Position, navigation, and timing (PNT) satellites make up another mission suited for the L2, L4, and L5 Lagrange points because of their ability to reach the near and far sides of the Moon. As lunar surface activity increases, PNT will enable lunar guidance capabilities like those on Earth.[12] Spacecraft in deep space currently require Earth-based ground sensors to determine the spacecraft's position and velocity, which is expensive due to the limited number of deep-space ground stations.[13] Position, navigation, and timing capabilities in cislunar space will enable space security functions such as autonomous navigation.

The low energy requirements to transit between Lagrange points and near-Earth orbits introduce another set of security challenges for US assets in near-Earth orbits.[14] The ability to keep a spacecraft at one of the Lagrange points using minimal fuel combined with the difficulty of monitoring these locations could enable the spacecraft to surreptitiously transition from the Lagrange point and interfere with US satellites in near-Earth orbits, giving operators little to no time to take defensive measures. The AsiaSat-3 telecommunications satellite is one example of how cislunar space can be used to affect near-Earth orbits and how similar techniques could threaten US cislunar space security.

AsiaSat-3 Case Study

In 1997, Russia launched a communications satellite to provide television and phone services in Asia for the Hong Kong-based Asia Satellite Telecommunications Company Ltd (AsiaSat). Yet the launching rocket failed to deliver the AsiaSat-3 satellite to GEO and left it in an unusable 51-degree inclination, "too low and too tilted relative to the

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[10] Spencer Kaplan, *Eyes on the Prize: The Strategic Implications of Cislunar Space and the Moon* (Washington, DC: Aerospace Security, Center for Strategic and International Studies [CSIS], July 13, 2020), 5, https://aerospace.csis.org/.

[11] Namrata Goswami, "China's Future Space Ambitions: What's Ahead?," The Diplomat, November 4, 2019, https://thediplomat.com/.

[12] Kaplan, *Eyes on the Prize*, 7.

[13] "CAPStm: A Peer-to-Peer Navigation and Communication Technology," Advanced Space (website), n. d., accessed November 12, 2023, https://advancedspace.com/.

[14] Parr et al., *Cislunar Security*, 1-3–1-4.

equator."[15] AsiaSat-3 did not have enough fuel to reach geostationary orbit because of the large amount of energy required to change inclinations and was declared a total loss.

Engineers from the company that built the satellite, Hughes Electronics Corporation, continued working on the problem and came up with a plan to use the Moon's gravity to assist the satellite into a nearly geostationary orbit.[16] This was possible since the fuel requirements to reach the Moon were less than that needed to change the orbital inclination. The gravitational assist from the Moon could then supply the energy to make the inclination change. The maneuver was successful and greatly improved the satellite's Earth orbit. The decision was made to make one more lunar assist maneuver, and after completion of the second lunar assist, the satellite was parked in geostationary orbit and available for use.[17]

AsiaSat-3 performed the first commercial mission to the Moon, but the real significance of the mission was the use of cislunar space to reach GEO.[18] The mission successfully demonstrated a novel method for a satellite to change Earth orbits using less onboard fuel; however, it also raised concerns that this movement strategy could be used aggressively in surprise attacks.[19] An adversary could launch a satellite on a translunar trajectory and then make orbit adjustments near the Moon to place it on course to intercept a US national asset.

The surprise comes into play because the interception comes from "above" the US asset in GEO, which is not typical. The adversary satellite may not be detected due to the lack of cislunar space domain awareness. Furthermore, hostile satellites could be parked in orbits at the Lagrange points ready to be used to disable US satellites. Due to the difficulty of keeping track of assets in cislunar space, the United States might have little to no time to take protective measures before it is too late.[20] Therefore, developing robust cislunar SDA is critical to US space security both in the cislunar regime and near-Earth orbits.

Space Domain Awareness in Cislunar Space

Space domain awareness is a critical cislunar technology. Understanding US adversary actions in cislunar space is the first step to achieving cislunar space security.[21] The US Space Force has been tasked to increase its surveillance to the cislunar region, which means a tenfold increase in range and 1,000 times increase in volume. Yet the

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[15] Andrew Pollack, "Trying to Save Satellite, Company Is Sending It to Moon," *New York Times*, April 30, 1998, https://www.nytimes.com/.

[16] Pollack.

[17] Hughes Global Services, Inc., "HGS-1 Arrives in Earth Orbit," press release, June 17, 1998, National Aeronautics and Space Administration (NASA) (website), https://solarsystem.nasa.gov/.

[18] Hughes Global Services.

[19] Kaplan, *Eyes on the Prize*, 5.

[20] Paul D. Spudis, "The Moon's Role in the New U.S. Space Force," *Smithsonian Magazine*, August 17, 2018, https://www.smithsonianmag.com/.

[21] Parr et al., *Cislunar Security*, 1-4–1-5.

Space Force is limited by current technologies and an architecture that was designed for a legacy mission.[22]

Several complicating factors make cislunar space domain awareness difficult. First, Earth-based and Earth-orbit-based optical and radar systems are very far from the regions of interest and provide poor resolution. Next, due to the chaotic nature of the orbiting body's motion in the three-body problem—the problem of determining the motion of three gravitationally interacting celestial bodies—determining orbital tracks is challenging. Finally, optical sensors placed in cislunar orbits need new algorithms to determine what is being viewed. To address these challenges, enabling technologies must be developed that consist of sensor placement, mission autonomy capabilities, orbit determination methodologies, and low-thrust propulsion.[23]

Electro-optical, infrared, and radar sensors each have advantages and limitations in performing space-domain-awareness missions. The sensor limitations are increased when trying to perform cislunar SDA since no single location in cislunar space provides coverage of the entire domain. Therefore, effective sensor placement is critical and should include sensors located on Earth, in near-Earth orbits, and in cislunar space. Assuming successful lunar-basing missions, sensor placement on the Moon could also help with cislunar SDA, but this is a much longer-term goal.[24]

Currently, most space observation sensors are either designed for Earth-orbit objects or for looking beyond the Moon. Yet the United States is engaged in advancing capabilities to leverage existing national, commercial, and academic sensors to provide coverage of the space between GEO and the Moon.[25] China is also looking to leverage existing sensors and is developing additional capabilities to provide the same coverage.[26]

Multiple sensors from different domains and locations need to work in coordination to effectively track objects in cislunar space since there is no predictable pattern the object must follow. Additionally, communication with sensors may not always be possible for certain locations in cislunar space. This makes managing the sensor constellation a difficult task and even more so for a large constellation. Therefore, cislunar sensors must have the ability to complete common tasks on their own and likely need to be able to make cooperative decisions between sensors autonomously. This includes letting the spacecraft determine its trajectory on the fly and collaborating with other sensor systems.[27]

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[22] James F. Bridenstine and John W. Raymond, Memorandum of Understanding between the National Aeronautics and Space Administration and the United States Space Force, NASA, September 2020, https://www.nasa.gov/.

[23] Parr et al., *Cislunar Security*, 3-5.

[24] Parr et al., 3-7–3-8.

[25] Sandra Erwin, "U.S. Space Force Sees Future Demand for Surveillance beyond Earth Orbit," *SpaceNews*, May 16, 2022, https://spacenews.com/.

[26] Kristin Burke, "China's Space Situational Awareness Capabilities for beyond GEO," Chinese Aerospace Studies Institute, Air University, September 12, 2022, https://www.airuniversity.af.edu/.

[27] Parr et al., *Cislunar Security*, 3-8.

Orbit determination methodologies for the two-body problem in near-Earth orbits are well established between algorithms and regular observation updates. The task is much more difficult in the three-body problem of cislunar space: including effects from the Moon result in chaotic motion of the spacecraft, where a small change in the initial condition can result in very large trajectory changes. New algorithms interpreted through machine learning may be helpful to predict spacecraft trajectories. Additionally, other inputs such as the desired behavior and operation of the spacecraft could enhance the orbit determination effectiveness.[28]

Finally, the ability to move freely through the cislunar orbit family members and orbit around convenient locations other than the Lagrange points would open new mission utility for sensors in cislunar space. Low-thrust technologies such as electric propulsion that operate continuously could enable the ability to orbit around artificial equilibrium points.[29] Low-thrust spacecraft also make it very challenging to track the spacecraft because the constant low thrust is difficult to distinguish from other perturbations. In addition to their use for SDA, low-thrust spacecraft have the potential to be used as tugs to move large amounts of material to and from the Moon.[30]

Because cislunar space domain awareness is critical to space security and to future utilization of cislunar space, both the United States and China are actively pursuing cislunar SDA capabilities. The following sections examine these activities to better understand these capabilities and the direction in which each country is moving.

China's Cislunar Space Domain Awareness Activities

Optical telescopes provide good capability to search for unknown objects in space. The majority of China's SDA optical telescopes are designed to focus on objects in low-Earth orbit and GEO. Yet the Chinese Academy of Science has a few telescopes used for astronomical studies that could possibly be used to detect objects in the space between the Earth and the Moon. Additionally, citizens and universities in China own and operate a variety of optical telescopes that could be used to help detect and track objects between geosynchronous Earth orbit and the Moon.[31]

Western astronomers demonstrated the feasibility of using publicly available passive radio frequency data combined with dedicated optical measurements from an academic telescope to demonstrate optical recovery and tracking of China's first lunar sample return mission on its journey all the way to the Moon.[32] China has the capability to employ the same techniques in the region between GEO and the Moon.

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[28] Parr et al., 3-10.

[29] Andrew D. Cox, "Transfers to a Gravitational Saddle Point: An Extended Mission Design Option for LISA Pathfinder" (master's thesis, Purdue University, April 2016), https://docs.lib.purdue.edu/.

[30] Parr et al., *Cislunar Security*, 3-9.

[31] Burke, "China's Space."

[32] Roberto Furfaro et al., "Tracking Objects in Cislunar Space: The Chang'e 5 Case" (technical paper, Advanced Maui Optical and Space Surveillance Technologies Conference [AMOS], Wailea, HI, September 15, 2021), https://amostech.com/.

Ground-based radio telescopes can be used to collect radio transmissions from transmitting satellites located beyond GEO. Multiple radio telescopes can be used together in a technique called very long baseline interferometry to simulate a much larger telescope aperture, thus enhancing resolution. China demonstrated the capability to use very long baseline interferometry collections with its Chang'e 5 lunar mission combined with X-band communication—communication via the secure and regulated super-high frequency range used primarily by the military and government—to precisely dock the Chang'e 5 ascender vehicle to the orbiter vehicle.[33]

Radio telescopes can also be used to identify unknown spacecraft movements and to discover unknown objects as shown by the Western astronomers who tracked Chang'e 5 as it moved from the Sun-Earth L1 point to a lunar distant retrograde orbit in 2022.[34]

China currently owns the world's largest radio telescope called the Five-hundred-meter Aperture Spherical Radio Telescope (FAST). Yet it only receives signals in L-band (70 MHz to 3 GHz)—the chief operating low frequency range used by applications such as radars, telecommunications, and global positioning systems—and cannot be used for S-, X-, or Ka-band transmissions without significant upgrades.[35] China is also currently building what will be the world's largest steerable radio telescope. The receiver will have a diameter of 110 meters and is expected to be completed in 2023. It will operate from 300 MHz to 117 GHz, covering the S-, X-, and Ka-bands.[36] Additionally, China plans to build a millimeter wavelength radio telescope in the Antarctic.[37]

Active ground-based radar detection of cislunar objects is difficult due to the energy requirements. Yet China is currently constructing a high-definition, deep-space radar facility codenamed "China Fuyan" (faceted eye) in Chongqing, China, that is expected to be able to detect objects 150 million kilometers from Earth.[38] China Fuyan will consist of over 400 distributed radar antennas with diameters of 25 to 30 meters.[39]

Three phases are planned for the project. In the first phase, four 16-meter diameter antennas will be constructed to verify the system's feasibility and test 3-D imaging of the Moon's surface. Two of the four antennas have currently been constructed. The plan for the second phase will increase the number of antennas to over 20, creating a distributed antenna with an equivalent diameter of 100 meters. The distributed system will verify the technology

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[33] Jia Wang et al., "Localization of the Chang'e-5 Lander Using Radio-Tracking and Image-Based Methods," *Remote Sensing* 13, no. 4 (2021), https://doi.org/.

[34] Ye Ruolin, "Amateur Astronomers over the Moon for Chang'e 5 Mission," Sixth Tone, December 8, 2020, https://www.sixthtone.com/.

[35] Rendonng Nan et al., "The Five-hundred-meter Aperture Spherical Radio Telescope (FAST) Project," *International Journal of Modern Physics D* 20, no. 6 (2011), https://doi.org/.

[36] Burke, "China's Space."

[37] Zhong Wang and Yanchun Liang, "An Overview of Some Latest Development in Chinese Astronomy," *Physical Sciences Anais da Academia Brasileira de Ciencias* 93, suppl. 1 (2021), https://doi.org/.

[38] Deng Xiaoci, "China Begins Construction on World's Most Far-reaching Radar System, to Boost Defense against Near-Earth Asteroid Impact," *Global Times*, July 10, 2022, https://www.globaltimes.cn/.

[39] Burke, "China's Space."

and is expected to detect objects tens of millions of kilometers from Earth.[40] The final phase is expected to extend the active observation range to 150 million kilometers.[41]

Chinese aerospace and technology officials stated the Fuyan radar will be used to study near-Earth asteroids and provide sensing capabilities for the Earth-Moon system. Plans are in place to use the radar to support the Tianwen-2 probe that will carry out a decade-long mission to observe a near-Earth asteroid and return samples from the asteroid. Tianwen-2 is expected to launch in 2025. The radar is also expected to monitor Chinese spacecraft missions to the Moon.[42] If the program is successful, the radar facility will become an integral part of China's cislunar space domain awareness capability.

With spaced-based SDA, China's Lunar Exploration Program demonstrated local SDA capabilities using optical sensors to conduct landing and systems checks and high-resolution images of the Moon.[43] China's future cislunar space-based SDA plans include developing sensors for a long-term lunar-based Earth observatory and enhancing their space-based very long baseline interferometry capabilities.[44]

US Cislunar Space Domain Awareness Activities

The United States is tackling the cislunar SDA problem using all three spacepower sectors: military, commercial, and civil. First, in April 2022, the United States stood up the 19th Space Defense Squadron (19 SDS) at Naval Support Facility Dahlgren, Virginia. The 19 SDS works with its sister squadron, 18 SDS, located at Vandenberg Space Force Base, California, to provide foundational space domain awareness and is responsible for maintaining custody of human-made objects in orbit, processing space events, and predicting the likelihood of on-orbit collisions.[45]

In addition to operating and maintaining several mission systems, 19 SDS was specifically created to focus on cislunar space domain awareness.[46] The 19 SDS works with the National Aeronautics and Space Administration (NASA), the Air Force Research Laboratory, and Space Systems Command to improve space security and defense. Specifically within the Space Force, 19 SDS is tasked to focus on cislunar sensors and systems deployed in cislunar space.[47]

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[40] Deng, "China Begins Construction."

[41] Burke, "China's Space."

[42] Deng, "China Begins Construction."

[43] Kaichang Di et al., "Geospatial Technologies for Chang'e-3 and Chang'e-4 Lunar Rover Missions," *Geospatial Information Science* 23, no. 1 (2020), https://doi.org/; and Leonard David, "A Tiny Chinese Lunar Orbiter Just Crashed on the Moon's Far Side (on Purpose)," Space.com, August 3, 2019, https://www.space.com/.

[44] Huadong Guo, Guang Liu, and Yixing Ding, "Moon-based Earth Observation: Scientific Concept and Potential Applications," *International Journal of Digital Earth* 11, no. 6 (2018), https://doi.org/; and Burke, "China's Space."

[45] "19th Space Defense Squadron," Peterson and Schriever Space Force Base, US Space Force, current as of January 2023, https://www.petersonschriever.spaceforce.mil/.

[46] "19th Space Defense Squadron"; and Jen Judson, "US Space Force Space Defense Squadron Tasked to Focus on Deep Space," C4ISRNET, April 20, 2022, https://www.c4isrnet.com/.

[47] Judson.

Looking at near-term solutions to the cislunar space domain awareness problem, 19 SDS leverages techniques studied in the Blue Horizons program at the US Air Force's Air War College during the 2022–2023 academic year.[48] The cislunar tracking study, called Project Rocket, used optical, passive radio frequency, and radar assets from the US Space Surveillance Network along with telescopes operated by universities and private companies to identify and track China's Chang'e 5 orbiter and Queqiao relay satellite, India's Chandrayaan-1 and Chandrayaan-2 lunar exploration missions, several NASA missions, and the James Webb Space Telescope.[49]

Project Rocket was supported by ExoAnalytic Solutions (Exo), headquartered in Foothill Ranch, California. Exo has been demonstrating cislunar SDA capabilities since 2020 using commercial solutions that are available today. In November 2022, Exo used its global network of over 350 telescopes at 35 sites around the world to test and demonstrate cislunar SDA by tracking the Artemis 1 mission as it traveled around the Moon and back to Earth.[50]

Long-term solutions for cislunar space domain awareness involve placing dedicated SDA sensors in cislunar space. The Air Force Research Laboratory is attempting to tackle the challenge of placing SDA spacecraft in cislunar space with its Oracle program—previously called the Cislunar Highway Patrol System. The Oracle spacecraft is planned for launch in 2026 with the aim to prove cislunar-sensing capabilities, provide operational experience in cislunar's complicated gravitational environment, and help mature communication and navigation technology near the Moon.[51]

Specific challenges the program will address include keeping the satellite in a halo orbit around the L1 Lagrange point so that it can look back toward Earth to detect potential threats and developing the algorithms necessary to autonomously process what the sensor sees.[52] If Oracle is successful, it will be strategically located to monitor activities in cislunar space better than terrestrial telescopes and Earth-orbiting satellites.[53]

NASA's Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) is another US program to test operating in cislunar space. CAPSTONE launched in June 2022 and entered its targeted near-rectilinear halo orbit in November 2022.[54]

In addition to providing information on using the near-rectilinear halo orbit, CAPSTONE will test the ability to communicate directly with NASA's Lunar Reconnaissance Orbiter that has been orbiting the Moon since 2009. The goal is for CAPSTONE to be

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[48] "Air Force Blue Horizons Fellowship Partners with ExoAnalytic to Collect Data on the Artemis I Launch," press release, ExoAnalytic Solutions, September 2, 2022, https://exoanalytic.com/.

[49] Erwin, "U.S. Space Force."

[50] "Blue Horizons Fellowship."

[51] "Oracle," Air Force Research Laboratory (website), accessed March 21, 2023, https://afresearchlab.com/.

[52] Theresa Hitchens, "Oracle's Vision: Understanding Cislunar Satellite Images Poses AFRL's 'Biggest' Challenge," Breaking Defense, November 28, 2022, https://breakingdefense.com/.

[53] Hitchens.

[54] Roxana Bardan, "CAPSTONE Forges New Path for NASA's Future Artemis Moon Missions," press release, NASA, November 21, 2022, https://www.nasa.gov/.

able to determine its position in space using data from the orbiter and CAPSTONE's autonomous navigation system, Cislunar Autonomous Position System, without the need to exclusively rely on tracking from Earth.[55] Finally, CAPSTONE will attempt to use an onboard chip-scale atomic clock to demonstrate one-way ranging, which could lead to position determination without the need for a dedicated ground link on the spacecraft.[56]

Not only is robust cislunar space domain awareness a challenging task, it is also a critical component of space security and an enabler for future advanced missions. Should Oracle and CAPSTONE prove successful, they could provide the foundational components of a US SDA architecture in cislunar space.

Additional Chinese Lunar and Cislunar Activities

Moving beyond SDA, China has multiple current and planned cislunar missions. Although China proclaims the peaceful use of space and its cislunar missions have thus far been scientifically focused, the advanced capabilities China has demonstrated present security concerns because of the potential to interfere with US spacecraft. Therefore, it is important to understand the achievements China has accomplished in cislunar space and possible future programs. To that end, the following section discusses China's retrograde GEO orbit and premier lunar exploration program.

Lunar Assist to Retrograde Geostationary Orbit

The AsiaSat-3 case study demonstrated how the Moon can be used to reach orbits that would otherwise be too costly in terms of energy. In 2021, authors from China's space telemetry, tracking, and command network headquarters, Xi'an Satellite Control Center, published an article in *Nature*'s *Scientific Reports* that investigated using lunar gravity assist to place a satellite in retrograde GEO (retro-GEO) for monitoring activities and debris warning.[57]

It is very difficult to launch directly to retrograde GEO because of the energy requirements to overcome launching against the rotation of the Earth. Yet as with the AsiaSat case, using cislunar space can reduce the energy requirements to reach the desired orbit. The *Scientific Reports* article concluded that the authors' calculations show it is possible to reach retro-GEO using the lunar assist method. The authors describe using a satellite in retro-GEO for updated debris warning every 12 hours.

Concerns have been expressed about placing a satellite in retro-GEO. The director of program planning for the Secure World Foundation, Brian Weeden, called it

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[55] Loura Hall, "What is CAPSTONE?," NASA, April 29, 2022, https://www.nasa.gov/.

[56] Bardan, "CAPSTONE."

[57] Bo-yong He, Peng-bin Ma, and Heng-nian Li, "Properties of the Lunar Gravity Assisted Transfers from LEO to the Retrograde-GEO," *Scientific Reports* 11, no. 18813 (2021), https://doi.org/; and Andrew Jones, "China Looked at Putting a Monitoring Satellite in Retrograde Geostationary Orbit via the Moon," *SpaceNews*, October 20, 2022, https://spacenews.com/.

"dangerous" since the satellite would be travelling at a much higher relative velocity to other satellites in GEO and in the opposite direction—similar to a car speeding down the wrong way on a freeway.[58]

In addition to the risk of collisions, a satellite in retro-GEO could survey the entire GEO belt every 12 hours and has the potential to disable or destroy adversary GEO satellites with little warning. The idea to use a lunar assist trajectory to place a satellite in retro-GEO that could then quickly destroy adversary satellites has been around for decades. In 1984, James Oberg published an article titled "Pearl Harbor in Space" that described exactly this concept.[59] The Chinese team cite this article in their *Scientific Reports* article but limit their stated application to debris warnings, thus ignoring the potential use for surprise offensive maneuvers.

Chinese Lunar Exploration Program

China is currently very active in cislunar space with its premier program, the Chinese Lunar Exploration Program (CLEP). This program was divided into three phases for goals before 2020: orbit the Moon, land on the Moon, and return from the Moon.[60] Although it just barely missed the timeline, China successfully achieved all three phases with the Chang'e 1 to 5 probes and demonstrated first-ever accomplishments. Chang'e 1 was launched in 2007 and was placed into low lunar orbit where it took high-resolution images of the Moon and surveyed the Moon for Helium-3.[61]

Chang'e 2, which launched in 2009, also performed a lunar mapping mission and identified landing locations for future missions.[62] Following the mapping mission, Chang'e 2 then transitioned to the Sun-Earth L2 Lagrange point and later rendezvoused with a near-Earth asteroid.[63] These two missions were important since Chang'e 1 successfully met CLEP's first goal to orbit the Moon and Chang'e 2 demonstrated China's ability to reach locations within and beyond cislunar space.[64]

The next two missions achieved CLEP's second goal to land on the Moon. Chang'e 3 launched in 2013 and performed a soft-landing on the Moon—a feat that had not been accomplished since the Soviet Union's Luna 24 mission in 1976 nearly 40 years prior.[65] The probe carried the Yutu lunar rover, which had operational challenges but still managed to gather information even after it lost the ability to move.[66]

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[58] Jones.

[59] James Oberg, "Pearl Harbor in Space," *OMNI Magazine* 6, no. 10 (1984), http://www.jamesoberg.com/.

[60] Xu Lin, Zou Yongliao, and Jia Yingzhuo, "China's Planning for Deep Space Exploration and Lunar Exploration before 2030," *Chinese Journal of Space Science* 38, no. 5 (2018), https://doi.org/.

[61] Kaplan, *Eyes on the Prize*, 8.

[62] Spudis, "Moon's Role."

[63] Kaplan, *Eyes on the Prize*, 8.

[64] Spudis, "Moon's Role."

[65] Rui C. Barbosa, "China's Chang'e-3 and Jade Rabbit Duo Land on the Moon," NSF [NASA Space Flight], December 14, 2013, https://www.nasaspaceflight.com/.

[66] Jeff Foust, "China's Immobile Rover Passes a Purely Figurative Milestone," *SpaceNews*, October 30, 2015, https://spacenews.com/.

In 2018, the Chang'e 4 lander launched and became the first-ever to land on the far side of the Moon.[67] The probe carried the Yutu-2 rover that is still operational today.[68] The Chang'e 4 mission is significant not only for being the first lander and rover on the far side of the Moon, but also because the mission includes the first-ever lunar relay satellite located in a halo orbit around the Earth-Moon L2 Lagrange point.[69] The relay satellite, named Queqiao, enables direct communications with the lander and rover.[70] CLEP's final goal to return from the Moon was given to the Chang'e 5 and Chang'e 6 missions. Chang'e 5 launched in November 2020 and successfully returned over 1.7 kilograms of lunar regolith—the layer of unconsolidated rock over the bedrock—back to Earth.[71]

Several technical feats were achieved with the Chang'e 5 mission. Four modules were used to complete the mission. Once the probe arrived in lunar orbit, the descender carried two modules, the ascender and the lander, to the lunar surface. After landing on the Moon's surface, the lander collected regolith and returned it to the ascender, which then lifted off the lunar surface and docked with the orbiter. After transferring the sample to the return capsule, the ascender jettisoned and crashed into the Moon. Five days later, the orbiter module entered a transfer orbit and started the return to Earth. Before arriving at Earth, the orbiter separated from the sample return vehicle and headed to the Sun-Earth L1 Lagrange point for further technology testing and to observe the Sun. The sample capsule successfully made the transition to the Earth's surface and was collected.[72]

After about six months at the Sun-Earth L1 point, the orbiter returned to the Earth-Moon system and demonstrated the first operational use of a distant retrograde orbit.[73] This orbit is important because of its orbital stability. This was a significant technical capability no other nation had accomplished. NASA's Artemis 1 mission has now also demonstrated use of the distant retrograde orbit.[74]

The Chang'e missions demonstrated China's ability to successfully maneuver throughout and beyond cislunar space as well as the ability to return to the Earth-Moon system after travelling to the Sun-Earth L1 point. The entire Chang'e 5 mission was tracked by amateur space enthusiasts using multiple observations from across the

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[67] Kaplan, *Eyes on the Prize*, 8.

[68] Andrew Jones, "China's Yutu 2 Rover Still Going Strong after 4 Years on the Moon's Far Side," Space.com, January 26, 2023, https://www.space.com/.

[69] Luyuan Xu, "How China's Lunar Relay Satellite Arrived in Its Final Orbit," Planetary Society (website), June 15, 2018, https://www.planetary.org/.

[70] Kaplan, *Eyes on the Prize*, 8.

[71] NASA Space Science Data Coordinated Archive (NSSDC), "Chang'e 5," NASA, accessed March 21, 2023, https://nssdc.gsfc.nasa.gov/.

[72] NSSDC.

[73] Andrew Jones, "A Chinese Spacecraft is Testing Out a New Orbit around the Moon," *SpaceNews*, February 15, 2022, https://spacenews.com/.

[74] Sandra Jones, "Artemis I – Flight Day 10: Orion Enters Distant Retrograde Orbit," *Artemis* (blog), NASA, November 25, 2022, https://blogs.nasa.gov/.

world to overcome small antenna sizes and limited equipment calibration.[75] The autonomous rendezvous and docking in cislunar space demonstrated by Chang'e 5 is a significant technical capability that no other nation has demonstrated. In addition to the technical achievement, however, it raises serious security concerns about China's ability to interfere with US spacecraft in cislunar space.

To achieve its next set of goals, China is working toward establishing a lunar research station by 2030.[76] The path to get there includes Chang'e 6, which was originally a backup in the event that Chang'e 5 failed. Yet with Chang'e 5's success, Chang'e 6 will now try a more complicated lunar sample return mission by returning samples from the lunar south pole and the far side of the Moon. China is also hosting payloads from France and Italy on Chang'e 6, and Russia and Sweden are other possible partners.[77]

Chang'e 7 is planned for a 2024 launch and is expected to include a cislunar telecommunications relay, a lunar orbiter, a lunar lander, a rover, and a flying probe.[78] The Chang'e 7 mission will be to study the lunar south pole.[79] The Chang'e 8 mission is still being finalized, but it is expected to have similar components as Chang'e 7—lander, rover, and flying probe—and will conduct experiments in preparation for establishing a lunar research station.[80]

As noted earlier, China's long-term goal is economic dominance of cislunar space. Beijing plans to accomplish this through incremental steps undertaken by its national space agency, consisting of developing advanced capabilities in all areas of space. Specific areas of focus include building launch capacity, developing a permanent space station, creating systems to enable supremacy in cislunar space, building a sustainable presence on the Moon, and maturing its systems for deep-space exploration.[81]

While the CLEP missions have been scientifically focused, they have been instrumental in developing and demonstrating capabilities needed for operating in cislunar space such as communications relays at the Lagrange points, payload transfers at the Lagrange points, and transit from the Lagrange points back to Earth orbits and from other heliocentric orbits.

The leadership structure of CLEP shows the People's Liberation Army (PLA) is involved with the program.[82] CLEP is one of the Chinese Communist Party's (CCP)

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[75] Jones, "Chinese Spacecraft."

[76] Kaitlyn Johnson, *Fly Me to the Moon: Worldwide Cislunar and Lunar Missions* (Washington, DC: Aerospace Security Project, CSIS, February 2022), 11, https://www.csis.org/.

[77] Andrew Jones, "China's Chang'e 6 Mission Will Collect Lunar Samples from the Far Side of the Moon by 2024," Space.com, July 8, 2021, https://www.space.com/.

[78] Xu Lin et al., "China's Lunar and Deep Space Exploration Program for the Next Decade (2020–2030)," *Chinese Journal of Space Science* 40, no. 5 (2020), https://doi.org/.

[79] NSSDC, "Chang'e 7," NASA, accessed March 21, 2023, https://nssdc.gsfc.nasa.gov/.

[80] Johnson, *Fly Me to the Moon*, 11.

[81] Goswami, "Space Ambitions."

[82] Kristin Burke, "Understanding China's Space Leading Small Groups—The Best Way to Determine the PLA's Influence," Chinese Aerospace Studies Institute, Air University, July 2022, https://www.airuniversity.af.edu/.

leading small groups—important permanent and ad hoc cells which operate within the Chinese government and CCP. The Party uses these cells to implement and coordinate policies nationwide. It has appointed the State Council to lead China's space leading small groups: CLEP and the China Manned Space Engineering program. This sets civilian control over CLEP. Yet even though the Central Military Commission is not in the leadership position, the Chinese military is still involved in the program. There are five subsystems that report to the chief designer and chief commander who runs the cell. Two of the five subsystems are led by the PLA. Therefore, it is not unreasonable to assume the PLA could leverage technology developed through CLEP for military purposes, highlighting the need for US decisionmakers to understand China's capabilities when building future strategies and force design.

Conclusion

Understanding the challenges of operating systems in cislunar space as well as possible security concerns from the United States' strategic competitor, China, contribute to achieving the US cislunar vision of fostering "the responsible, peaceful, and sustainable exploration and use of Cislunar space."[83] Robust cislunar space domain awareness is the first step to achieving security in cislunar space and from effects initiated in cislunar space on near-Earth orbiting spacecraft. Yet domain awareness in cislunar space is challenging due to the large distances from the Earth and the difficulty predicting orbital paths. Both the United States and China are investigating methods to use existing capabilities for the cislunar SDA challenge. Additionally, both nations are working to put sensors in cislunar space to increase their cislunar SDA capability.

China has demonstrated advanced technologies in cislunar space with the Chinese Lunar Exploration Program. Through CLEP, China has shown the capability to use the Earth-Moon Lagrange points as transfer stations for spacecraft, land on the Moon and bring regolith back to the transfer vehicle, return Moon samples to the Earth, and transition between Sun-Earth Lagrange points, Earth-Moon Lagrange points, and near-Earth orbits.

Since the role of cislunar space and the Moon will continue to expand in space, and therefore impact national security, the United States must maintain current knowledge of strategic competitor activities in cislunar space. Increasing cislunar space domain awareness and the ability to track objects in cislunar space are key components to achieving comprehensive space domain awareness. *Æ*

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[83] Technology Interagency Working Group, *National Cislunar Science*, 2.

SPACE WEAPONIZATION

REEXAMINING THE HISTORICAL AIR ANALOGY TO SPACE

Benjamin M. Staats

A history of airpower that sources airpower's origin to the late eighteenth-century introduction of balloons rather than to the early twentieth-century introduction of airplanes provides an accurate and pertinent analogy for states' development of space domain use and, in particular, the weaponization of space. Airpower experienced gradual growth throughout the nineteenth century. In the early twentieth century, the nexus of technological, geopolitical, and legal conditions facilitated the air domain's rapid and intense weaponization. This history of airpower is analogous to what has occurred in space beginning in the early 1960s, leading to the current emerging era of rapid and intense space weaponization.

In 1962, Air Force Chief of Staff Curtis E. LeMay faced the challenge of navigating decisions on space weaponization. He reasoned that spacepower, analogous to twentieth-century airpower, would rapidly transition from serving primarily reconnaissance purposes to serving primarily offensive ones.[1] Yet his assessment proved wrong less than a year later when the Kennedy administration reaffirmed the "space for peace" policy, and the interagency committee reviewing disarmament negotiations and the peaceful uses of space decided against the military pursuit of any deliberate space weaponization efforts.[2]

As a result of these decisions, the United States prioritized space-based reconnaissance throughout the twentieth century. Contrary to LeMay's thinking, although individual offensive-focused space weaponization efforts certainly materialized to some degree throughout the Space Age, the pace and extent of the development of space weapons did not fully resemble the rapid and intense development of air weapons during the early twentieth century, in the period leading up to and through World War I.

Yet LeMay and others who have since thought about the development of spacepower are fundamentally mistaken in comparing this with the currently accepted but

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[1] David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership*, rev. ed. (Maxwell AFB, AL: Air Force Space Command in association with Air University Press, 1998), 102.

[2] Spires, 104–12.

incomplete view of the historical development of airpower. In fact, the evolution of airpower did not begin with the Wright brothers' first mechanized flight in 1903; it began over a century before in the same way spacepower developed—when humans could exploit the air domain to achieve real benefits, such as cartography, urban planning, and military reconnaissance.[3] Thus, according to visionary Billy Mitchell's simple definition of airpower as the "ability to do something in the air," the origins of airpower can be traced back to the first true aircraft—the balloon.[4]

The evolution of airpower, marked from the beginning of the human-flight era in balloons, appropriately informs how space strategists and policymakers should think about the evolution of spacepower, and more specifically, space weaponization. For the purposes of this analysis, a space weapon can be defined as "any space-based or terrestrial-based weapon that achieves kinetic or non-kinetic destructive effects in space, conflicts with the peaceful uses of space, and threatens to destabilize space security."[5]

Tracing the origins of airpower to the advent of the balloon illustrates that the progression and nexus of technological, geopolitical, and legal conditions in the early twentieth century do in fact mirror an identical progression and nexus of such conditions today, giving rise to the emerging era of rapid and intense space weaponization. As states overcome technological limitations and exploit the space domain to achieve political objectives within a permissive legal environment, they set conditions for a new era of greater weaponization. That moment for space was not 1962 as LeMay had reasoned; instead, as a revised view of the history of airpower illustrates, the moment for this new era of space weaponization is now.

Space weaponization has certainly advanced over the past few decades, but the coming era will be characterized by even more rapid and intense progress. Moreover, the United States must anticipate this increased pace of weaponization and pursue deliberate geopolitical options to mitigate the risk of conflict escalating into and through space.

Reexamining the Airpower Analogy to Space

Some experts have questioned the validity of drawing any kind of strategic or historical analogy between the evolution of airpower and spacepower; however, such a comparison can help inform the ongoing development of spacepower and

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[3] Jason Pearl, "The View from Above: Satiric Distance and the Advent of Ballooning in Britain," *Eighteenth-Century Studies* 51, no. 3 (Spring 2018): 275.

[4] William Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power—Economic and Military* (Tuscaloosa: University of Alabama Press, 2010), xii.

[5] Crockett L. Grabbe, *Space Weapons and the Strategic Defense Initiative* (Iowa City: Iowa State University Press, 1991), 13.

space weaponization.[6] The generally accepted historical analogy itself is not problematic; it is simply incomplete. Rather than beginning in the twentieth century with the airplane and the first powered flight, the evolution of airpower and the air domain actually began in the late eighteenth century as states and militaries attempted to militarize and weaponize the air domain with balloons.[7]

A more historically complete analysis of the evolution of airpower and air weaponization uncovers a number of parallel developments across theory, militarization, and weaponization in the nascent history and evolution of spacepower and space weaponization not previously realized. Specifically, the actual evolution of airpower and air weaponization, dating back to the 1790s, remedies three common concerns raised when comparing the evolution of airpower to spacepower.

Concern 1: The air and space domains evolved at drastically different paces.[8] In fact, it took well over a century from the first organized, trained, and equipped company of French military aérostiers (airmen) who conducted military aerial reconnaissance in battle in 1794, until military airpower and the air domain became fully weaponized in the early twentieth century.[9] This contrasts with the historical view of rapid airpower evolution in the twentieth century myopically focused on airplane evolution. In actuality, the air and space domains evolved at very similar paces.

Concern 2: The temporary abandonment of space weapons has no parallel precedent in the history of airpower.[10] In reality, however, many states engaged in efforts to weaponize the air domain prior to the twentieth century with balloons and dirigibles. For example, Austria successfully launched over 200 balloon bombers over Venice in 1849, yet it did not attempt to employ similar efforts again until decades later with bomber planes.[11] Throughout the nineteenth century, other states, such as Russia and Germany, attempted to weaponize balloons and dirigibles in one way or another, but those advocating for such efforts never achieved the political will or senior military

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[6] James E. Oberg, *Space Power Theory* (Washington, DC: Government Printing Office, 1999), 121–22; Karl P. Mueller, "Totem and Taboo: Depolarizing the Space Weaponization Debate," in *Space Weapons: Are They Needed?*, ed. John M. Logsdon and Gordon Adams (Washington, DC: Space Policy Institute, Elliot School of International Affairs, 2003), 21–22; and Barry D. Watts, *The Military Use of Space: A Diagnostic Assessment* (Washington, DC: Center for Strategic and Budgetary Assessments, February 2001), 32–33.

[7] Caren Kaplan, "The Balloon Prospect: Aerostatic Observation and the Emergence of Militarized Aeromobility," in *From Above: War, Violence and Verticality*, ed. Peter Adey, Mark Whitehead, and Alison Williams (London: C. Hurst & Co., 2013), 19–20.

[8] Watts, *Military Use*, 33; and Mueller, "Totem and Taboo," 21–22.

[9] Charles Coulston Gillispie, *Science and Policy in France: The Revolutionary and Napoleonic Years* (Princeton, NJ: Princeton University Press, 2004), 371–72.

[10] Mueller, "Totem and Taboo," 22.

[11] Charles A. Ziegler, "Weapons Development in Context: The Case of the World War I Balloon Bomber," *Technology and Culture* 35, no. 4 (October 1994): 751–52.

leader buy-in.[12] Thus, there were periods throughout the history of airpower when air weapons were temporarily abandoned.

Concern 3: A lack of codified spacepower theory followed the Persian Gulf War in 1990. The fact that no formal spacepower theory exists presumably and conclusively distinguishes spacepower evolution from airpower evolution, which does have a generally accepted collection of theories beginning with mechanized flight.[13]

Yet airpower theory can be traced back to its beginning with balloons, more than a century prior to current formal airpower theory. Several strategists and statesmen, including Benjamin Franklin and Thomas Jefferson, as well as one of the first aeronauts, André Giraud de Villette, began writing about airpower theory following the first human balloon flight in 1793. These writings discussed the utility of balloons for reconnaissance in addition to issues such as communications, troop transport, siege support, and even strategic bombing.[14]

In contrast to the assumption that airpower thought emerged rapidly following the first mechanized flight, following World War I, visionaries Giulio Douhet and Mitchell therefore had an entire century of experiences and history, in addition to a world war, to substantiate their theories. Thus, airpower and spacepower evolution generally mirror each other in that their first 60 or so years witnessed the emergence of their theoretical foundations.

In addition to the insights above, several other parallel themes support the accurate evolution of airpower as a legitimate historical analogy to the development of spacepower.

Reconnaissance

The primary purpose of airpower throughout the first century of airpower evolution was reconnaissance. Similarly, reconnaissance was, and arguably still is, the primary purpose of spacepower.[15] Moreover, the reconnaissance mission evolved and expanded in respective airpower and spacepower histories. In the Civil War, various Union Army commands employed military balloons to complement tactical ground reconnaissance efforts. Additionally, these commands conducted untethered deep/strategic reconnaissance and employed them to direct artillery and mortar fire.[16]

In the evolution of spacepower, satellite reconnaissance missions have evolved and expanded from strategic reconnaissance to the US military employing a range of

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[12] Alexander Rose, *Empires of the Sky: Zeppelins, Airplanes, and Two Men's Epic Duel to Rule the World* (New York: Random House LLC, 2020), 45–46; and Charles M. Evans, *The War of the Aeronauts* (Mechanicsburg, PA: Stackpole Books, 2002), 61–62.

[13] James Andrew Lewis, "Neither Mahan or Mitchell: National Security Space and Spacepower, 1945–2000," in *Toward a Theory of Spacepower: Selected Essays*, ed. Charles D. Lutes and Peter L. Hays (Washington, DC: National Defense University, Institute for National Strategic Studies, 2011), 286.

[14] Kaplan, "Balloon Prospect," 26, 39; and Clare Brant, "The Progress of Knowledge in the Regions of the Air?: Divisions and Disciplines in Early Ballooning," *Eighteenth-Century Studies* 45, no. 1 (Fall 2011): 74–76.

[15] Simon P. Worden, "Future Strategy and Professional Development: A Roadmap," in *Theory of Spacepower*, 569; and M. V. Smith, "Security and Spacepower," in *Theory of Spacepower*, 331, 349.

[16] Evans, *Aeronauts*, 112–13, 130–34, 159–60.

space-based sensors to provide intelligence, surveillance, and reconnaissance (ISR) in support of operational and tactical military operations, including the integration of sensor-to-shooter concepts.

Operational Constraints

Early reconnaissance balloons and satellites achieved unintended psychological effects and placed constraints against opposing forces.[17] A Confederate artillery chief, Edwin Porter Alexander, described the Union Army's employment of balloons as such:

> I have never understood why the enemy abandoned the use of military balloons. . . . Even if the observers never saw anything, they would have been worth all they cost for the annoyance and delays they caused us in trying to keep our movement out of their sight.[18]

Reconnaissance satellites have had the same effects. States regularly change their conduct of military and other security affairs to avoid satellite detection.[19]

Institutional Structures

Finally, governments and militaries worldwide have created institutions and programs specifically for air and space domains, with air domain examples dating to the late eighteenth century. The French Proving Grounds of Meudon, a weapons research and development site, established the first military unit designated to train for aerial warfare in 1793. Less than a year later, France deployed a company of aérostiers and their balloon, L'Entreprenant, into battle in 1794.[20] In another example, President Abraham Lincoln established an air institution, the Army Aeronautics Corps, by presidential directive during the Civil War.[21]

Likewise, in the late 1950s, the United States established a range of space programs and institutions, beginning with the first joint Central Intelligence Agency-Air Force reconnaissance satellite programs, CORONA and WS-117L.[22] In 1961, the United States established Air Force Systems Command, followed by Air Force Space Command in 1982, while the Soviet Union launched its Soviet Space Program, which evolved into dualistic efforts of prestige and military exploitation and superiority.[23]

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[17] Gillispie, *Science and Policy*, 373.

[18] Ben Fanton, "View from above the Battlefield," *America's Civil War* 14, no. 4 (September 2001): 29.

[19] Smith, "Security and Spacepower," 331–32.

[20] Charles Coulston Gillispie, "Science and Secret Weapons Development in Revolutionary France, 1792–1804: A Documentary History," *Historical Studies in the Physical and Biological Sciences* 23, no. 1 (1992): 132; and Gillispie, *Science and Policy*, 371–72.

[21] Evans, *Aeronauts*, 69–71, 86–87.

[22] Bernard A. Schriever, "Military Space Activities: Recollections and Observations," in *The U.S. Air Force in Space: 1945 to the 21st Century* (Washington, DC: USAF History and Museums Program, 1998), 15–16.

[23] Spires, *Beyond Horizons*, 90, 194, 205–8; Walter A. McDougall, *...The Heavens and the Earth: A Political History of the Space Age* (Baltimore, MD: John Hopkins University Press, 1997), 237, 273–75.

Airpower and spacepower histories clearly evolved similarly regarding pace, weaponization, and theory development. Both histories illustrate how air and space systems generated effects against opponents as they altered other states' behavior. Both histories also show the deliberate establishment of military organizations to exploit their respective domains.

Thus, as the nature of analogy is defined, if two or more of the aspects between air and space evolution agree in some respects, then they are likely to agree in others. And although historical analogies can lead to "insidious fallacies," when aligned appropriately, as in the case of airpower and spacepower, these analogies can provide important insights into how spacepower and particularly the weaponization of space might continue to evolve, including major determinants for potential challenges.[24]

Keys to Rapid and Intense Weaponization

Given it took well over a century until air platforms completely transitioned from serving primarily reconnaissance purposes to serving offensive purposes, it may take a similar timeline for space. As LeMay thought, this transition may, however, be characterized by the same rapid and intense weaponization as the air domain saw in the early twentieth century. Indeed, the right set of conditions appear to be converging to cause that situation to unfold. Reconsidering the evolution of airpower reveals three key factors were necessary for the rapid and intense weaponization of the air domain, all of which are mirrored today in the space domain: overcoming technological limitations, achieving political objectives, and having a permissive legal environment.

Technological Limitations

States demonstrated it was technologically challenging to weaponize the air and space domains throughout history because of technological immaturity and the resulting employment of more feasible alternative domain options. But both histories also reveal that as technology advanced and the costs and risks associated with the technology decreased, it became easier to weaponize domains.

Throughout the nineteenth century, states invested in proposed balloon bomber plans only to realize the primitive technology available at the time resulted in ineffective weapon platforms. For example, Denmark attempted to use handheld dirigibles, or balloons with propulsion, against a British naval blockade in 1807, but the plan failed.[24] Five years later, Russia initiated the design of a dirigible to bomb Napoleon's camp, but it also failed because of multiple design problems.[25] Russia's attempt to develop an offensive airship proved unsuccessful again in the 1890s, along with the first

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[24] Tyler Morton, *From Kites to Cold War: The Evolution of Manned Airborne Reconnaissance* (Annapolis, MD: Naval Institute Press, 2019), 28.

[25] Ziegler, "Weapons Development," 751.

versions of the German Zeppelin airship bombers, which had no real developmental success until the eve of World War I.[26]

Technological limitations stifled the weaponization of the space domain as well. The Dyna-Soar manned space bomber (X-20) and its follow-on replacement program, the National Aerospace Plane, both faced considerable technical problems.[27] Other space-based weapons, such as a kinetic bombardment from space—the so-called "Rods from God"—and Space Defense Initiative (SDI) space-based missile interceptors named "Brilliant Pebbles," faced technical challenges related to reentry, flight control, and guidance.[28] Space-based chemical lasers and mirrors associated with SDI also proved to be highly challenging to such an extent that some concluded the weapons were unachievable at any cost.[29]

As a result of technological limitations, more feasible alternative domain weapon options overshadowed the need to advance the immature technology needed to weaponize the new domains. Other weapon technologies could more effectively achieve near-identical effects, ultimately stunting the necessary investment to overcome the technological limitations needed to weaponize the respective domains. Throughout the nineteenth century, there was little incentive for this investment with balloons when artillery employment techniques, ranges, precision, and other related gun technologies continued to improve, offsetting the need for an aerial bomber.[30] Further, throughout the nineteenth century, the preponderance of military generals presumed ground-based reconnaissance was significantly more reliable than reconnaissance via balloons, undermining any further investments and support to the latter's development.

Similarly, regarding the advancement of space weaponization, the development of ground, sea, and air-based weapons in the twentieth century provided alternative options that were supposedly much more affordable and politically risk averse.[31] For example, ground- and sea-based missile interceptors could destroy ballistic missiles—at least to a capacity that was politically acceptable—and ground-based antisatellite weapons (ASATs) could feasibly destroy enemy satellites. Despite the successful testing and validation of many Brilliant Pebbles technologies necessary for space-based interceptors, such as new sensors in space via the NASA Clementine program, it appeared challenging to justify continuing investment when other domain weapon technologies could achieve similar effects, whether or not this was actually the case.[32]

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[26] Rose, *Empires*, 46–47.

[27] James Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, 2nd ed. (Redwood City, CA: Stanford University Press, 2011), 152, 194.

[28] Moltz, 295.

[29] Moltz, 201.

[30] Ziegler, "Weapons Development," 752.

[31] Henry F. Cooper, "Space Defense: An Idea Whose Time Has Come?," in *Spacepower for a New Millennium: Space and U.S. National Security*, ed. Peter L. Hays et al. (New York: McGraw-Hill, 2000), 129–37.

[32] Cooper, 132–33; and Donald R. Baucom, "Space and Missile Defense," *Joint Force Quarterly* (Winter 2002): 55.

Still, the history of air weaponization demonstrates states eventually overcame these technological limitations. For over a century, balloons were the only option for exploiting the air domain. Yet two key technological breakthroughs—the refinement of lightweight aluminum alloys and the internal combustion engine—enabled the potential for future airplanes and Zeppelin airships.[33] The innovation of the airplane and the Zeppelin was still a matter of high risk and/or high cost, however, and success did not materialize until innovators gathered the time and resources to invest into their potential innovations.

Less than eight years before the Wright brothers' first flight, leaders in the scientific community deemed the airplane to be an impossible technology.[34] It is not clear what technologies, or amalgamation of technologies—for example, propulsion, energy, sensors, artificial intelligence—will enable the greater feasibility of space weaponization, but it will only be a matter of time as space-related technology continues advancing, proliferating, and diffusing. Such technology also may have already presented itself.

Political Objectives

As late as the turn of the twentieth century, states did not need to weaponize the air domain to ensure their security. For example, in the 1890s, France's military balloon development and reports of Russia's aircraft construction threatened Germany's security, triggering Germany to initiate efforts to build an airship as well.[35] Soon, however, it became evident Russia's airship was a complete failure, and France's balloons were no more effective than previous versions. This realization on Germany's part deescalated the security dilemma and led to the Prussian Aeronautical Battalion dismissing Count von Zeppelin's airship proposal in 1895.[36]

Nevertheless, the political incentive to weaponize the air domain returned permanently by 1907 when Russia, France, and Great Britain became allied and formed the Triple Entente. In response Germany reappraised its military, including views on new military capabilities such as an offensive airship, the Zeppelin, to gain a future advantage through the conduct of strategic bombing raids.[37]

In the case of the space domain, when the United States sought to eliminate the security threat of nuclear weapons via SDI in the 1980s, the most practical and attainable solution to achieve this political objective required the employment of space-based kinetic kill vehicles—eventually the Brilliant Pebbles concept—that would have increasingly weaponized space.[38] Yet regardless of the technological feasibility of Brilliant Pebbles and other potential missile defense programs such as

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33. Rose, *Empires*, 42–45.
34. Everett C. Dolman and Henry F. Cooper Jr., "Increasing Military Uses of Space," in *Theory of Spacepower*, 376.
35. Rose, *Empires*, 46–47.
36. Rose, 48–50.
37. Rose, 89.
38. Lester L. Lyles, "Space and Ballistic Missile Defense Programs," in *Spacepower*, 113–15.

space-based lasers, the United States ultimately canceled them for political reasons, given sensitivities to weaponization.[39]

Also, by the late 1800s, air weapons did not appear to enable the accomplishment of security-related political objectives because at that time they were not effective at precision strikes. For example, throughout the nineteenth century, there was a lack of strategic targets against which to employ balloon bombers, and as previously stated, artillery could achieve identical tactical and long-range precision effects. But as agrarian societies began to industrialize around the turn of the twentieth century, newly established industrial centers became potential strategic bombing targets.[40] Thus, it became increasingly evident that states needed to employ air weapons to enhance their ability to achieve political objectives tied to targeting industrial centers.

Similarly, in the early space age, the Kennedy administration demonstrated it had no political will to weaponize space because it could achieve its political objectives, specifically security, via civil competition for prestige instead. Despite a heavy push by the US Air Force to develop space weapons, the Kennedy administration reaffirmed the "space for peace" policy, and the interagency committee reviewing the program decided against space weaponization.[41] Yet space is increasingly valuable to states, and space-related infrastructure—particularly space-based infrastructure—is at greater risk as states can now target them to achieve political objectives.

Permissive Legal Environment

Even a legal framework appears insufficient to prevent space weaponization. A codified international legal framework or strong code of conduct can raise the threshold for weaponization, but the historical air domain analogy demonstrates the limitation of such. The first Hague Peace Conference in 1899 included the adoption of Declaration XIV, Prohibiting the Discharge of Projectiles and Explosives from Balloons.[42] Although this likely slowed official state-sponsored development of aerial weapons systems, it did not prevent military strategists and early airpower advocates from considering the ability of such weapons to achieve military and political objectives.

When Declaration XIV expired in September 1905, technological advancements in air platforms were much further along. By 1907, the Second Hague Peace Conference met and proposed renewing Declaration XIV, but the new technological potential combined with ongoing security tensions and the formation of the Triple Entente led to most major states choosing not to sign or ratify it. To mitigate this new risk, drafters inserted Article 25 into Declaration IV, Laws and Customs in Land Warfare, which

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[39] Dolman and Cooper, "Military Uses of Space," 377.

[40] Ziegler, "Weapons Development," 753.

[41] Spires, *Beyond Horizons*, 104–12.

[42] Hague Declaration (XIV) on Explosives from Balloons, 1907, ICRC [International Committee of the Red Cross] International Humanitarian Law (IHL) Databases, accessed December 2, 2021, https://ihl-databases.icrc.org/.

stated, "The attack or bombardment, by whatever means, of towns, villages, dwellings, or buildings which are undefended is prohibited."[43]

In addition, the international community reinforced this legal framework with the practice of a strong code of conduct. During this period, states adhered to generally accepted, unwritten "rules of war."[44] There was a military code and ethos that limited the number of attacks against noncombatants—unless, of course by tradition, they were in a besieged city—and states and generals perceived the strategic bombing of civilians as a violation of such.[45]

Nevertheless, Germany still developed the Zeppelins as strategic bombers leading up to World War I, while other state militaries continued to test offensive bomber capabilities with airplanes. When World War I broke out, the legal framework and code of conduct for constraining states' air weaponization collapsed, demonstrating the ultimate limitations of such efforts in the face of technological and political conditions.

The legal constraints in space law present similar themes. First, international space law legalized the militarization of space, banning only weapons of mass destruction and nuclear weapons.[46] Second, space-based weapons are not illegal, yet a generally accepted code of ethics prevails that serves to constrain those who would attempt to, at least openly, deploy space-based weapons.[47] Attempts in the 2008 Conference of Disarmament to prevent the employment of space-based weapons remain in gridlock since proposed agreements are propaganda tools that deliberately offer only politically unacceptable terms to the United States.[48] Lastly, the similar legal framework and code of ethics, along with the rising security tensions between the major space actors—the United States and its Allies, China, and Russia—present similar political dynamics combined with increasing investments in space-related technologies that will spur an era of rapid and intense space weaponization.

Certainly states will continue to overcome technological limitations to develop space weapons, as many technologies originating from benign purposes have inevitable applications as potential weapons. Given that it is irrational to constrain such technological advancements and often unfeasible to restrict weapons development, the only condition states can reasonably control is the political threshold. Consequently, this reveals that space weaponization and conflict in space are not just space policy challenges, but rather, they are fundamentally geopolitical challenges. The growing weaponization of space, described in the next section, indicates the inter-

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[43] Hague Convention (IV) on War on Land and Its Annexed Regulations, 1907, ICRC IHL Databases, accessed December 2, 2021, https://ihl-databases.icrc.org/.

[44] Gwynne Dyer, *War: The Lethal Custom* (New York: Carroll & Graf Publishers, 2004), 76.

[45] Ziegler, "Weapons Development," 754.

[46] McDougall, *Heavens*, 274.

[47] Michael E. O'Hanlon, *Neither Star Wars nor Sanctuary: Constraining the Military Uses of Space* (Washington, DC: Brookings Institution, 2004), 109.

[48] Christina B. Rocca, "Analysis of a Draft 'Treaty on Prevention of the Placement of Weapons in Outer Space, or the Threat or Use of Force against Outer Space Objects' " (United Nations Conference on Disarmament, Geneva, Switzerland, August 26, 2008), https://undocs.org/.

national community will continue to progress toward greater degrees of space weaponization unless states pursue deliberate political decisions to avoid or mitigate it.

Expansion of Space Weaponization

Twenty years ago, space expert Everett Dolman argued the world was right in the center of the weaponization scale between the two extremes of complete sanctuary and total weaponization.[49] Whether that was accurate or not matters less so than the fact that the world is much closer to complete weaponization than it was at that time.

As the arms control community, specifically the Union of Concerned Scientists, pointed out in the 1980s, terrestrial space weapons present the same degree of threat to space security as do space-based weapons.[50] Yet while the general space community once agreed with some form of the space weapon definition provided early in the article, over the past few decades the development and deployment of terrestrially-based space weapons have somehow become more permissible than space-based weapons. Unfortunately, this goal-post shifting disingenuously obscures noncompliant applications of dual-use technology under international law and highlights the evolution of space weaponization over the past few decades. This concept becomes clear when analyzing this period of space weaponization expansion.

Cross-Domain Space Weapons

To further define what qualifies as a space weapon, one must consider that the space domain is not isolated nor inaccessible from terrestrial cross-domain weapons that are ground-, sea-, air-, and cyber-based. An increasing number of actors have either developed, tested, and/or validated terrestrial-based direct-ascent ASAT weapons, directed-energy weapons, electronic warfare, and/or cyber weapons to some degree against space-based systems.[51]

These cross-domain weapons are inherently space weapons. Many actors can now employ cross-domain weapons into the space domain, in the exact same manner as they do with weapons from one terrestrial domain into another. These weapons and their intended effects clearly illustrate that space weaponization is not only an existing challenge but also much further along than in years past.

Co-Orbital ASAT Weapons

Russia's Burevestnik and Nivelir programs deliberately test on-orbit interceptors. These systems, along with other potential co-orbital ASATs, can damage or destroy a

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[49] Everett C. Dolman, "Space Power and US Hegemony: Maintaining a Liberal World Order in the 21st Century," in *Space Weapons*, 48.

[50] Richard L. Garwin, Kurt Gottfried, and Henry W. Kendall, *The Fallacy of Star Wars: By Union of Concerned Scientists*, ed. John Tirman (New York: Vintage Books, 1984), 227–36.

[51] Todd Harrison et al., *Space Threat Assessment 2021* (Washington, DC: Center for Strategic and International Studies [CSIS], March 2021).

target using hypervelocity collision, releasing projectiles, employing a robotic arm, and/or using close-range directed-energy weapons.[52] US Space Command characterized these types of activities as hostile and aggressive and emphasized they were clear Russian efforts to develop and test space-based weapons.[53] Yet Russia claims these tests were simply inspection-related activities that did not amount to the deployment of weapons in outer space.[54] Russia's rhetoric takes advantage of the dual-use dynamic of space that increasingly facilitates the discreet weaponization of space via rendezvous and proximity operations (RPO) capabilities.

Rendezvous and Proximity Operations Weapons

Space actors are also developing and testing emerging dual-use RPO capabilities, such as active debris removal or on-orbit satellite servicing, with the potential to employ them as space weapons and threaten other space systems. Despite their often benign designs, the uncertainty regarding their intent induces ambiguity and insecurity in the space domain. For example, a Chinese civil space agency with close ties to the People's Liberation Army may operate active debris removal or on-orbit satellite servicing capabilities as part of its military-civil fusion where the army has the authority to employ an already on-orbit system as a weapon to achieve political-military objectives.

High-Altitude Nuclear Detonations

High-altitude nuclear detonations (HAND) or high-altitude nuclear explosions represent a unique cross-domain space weapon deserving of its own category. Not only have the United States and the Soviet Union tested the detonation of nuclear bombs in space, but also the first test, Starfish Prime, essentially disabled seven low-Earth-orbit satellites, one-third of the existing satellites in space.[55] Given today's modernized nuclear arsenals, radiation from just one detonation could potentially disable all nonhardened low-Earth-orbit satellites over time.[56] There are a number of geopolitical scenarios where a state conducts a HAND in response to a security threat.[57] Further, a HAND may never have to reach space or orbit to achieve some level of effect on very-low-Earth-orbit satellites as the charged particles from the blast may extend into space.

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[52] Brian Weeden, *Russian Co-orbital Anti-satellite Testing* (Broomfield, CO: Secure World Foundation, 2023), 1–2, https://swfound.org/.

[53] US Space Command (USSPACECOM) Public Affairs Office, "Russia Conducts Space-based Anti-satellite Weapons Test," USSPACECOM, July 23, 2020, https://www.spacecom.mil/.

[54] Harrison et al., *Space Threat Assessment*, 14, 22; and Brian Weeden and Victoria Samson, *Global Counterspace Capabilities: An Open Source Assessment* (Washington, DC: Secure World Foundation, April 2021), 2–9.

[55] Daniel G. Dupont, "Nuclear Explosions in Orbit," *Scientific American* 290, no. 6 (June 2004): 100–102.

[56] Peter L. Hays, *Space and Security: A Reference Handbook* (Santa Barbara, CA: ABC-CLIO, 2001), 88.

[57] Dupont, "Nuclear Explosions," 107.

Due to technological and geopolitical conditions, the total number of these space weapons, the number of actors with access to them, and the severity of consequences they present to space security, demonstrate the space domain is indeed already weaponized to a large degree. Further, the international community places constraints only on overt space-based weapons. This situation essentially grants terrestrial-based and on-orbit dual-use, multiple-intent space weapons de jure (inherently legal) status, but applies a de facto illegal status for overt space-based weapons.[58] This places open and transparent states at greater disadvantages against states such as China whose strategies deliberately refrain from revealing specific capabilities.[59] Thus, the United States and its Allies and partners can no longer assume the survivability of their own satellites without developing capabilities to deter adversaries from attacking them.[60]

Conclusion

Although the time frame of LeMay's analogy was in error—his assessment for space weaponization was roughly 60 years early—his assumptions were right: there would come a time when the primary purpose of spacepower shifts from reconnaissance to offense.

Given the expansion of space weaponization and its continued trajectory under the nexus of the current technological, geopolitical, and legal conditions, one should expect an emerging era of rapid and intense space weaponization in the near future identical to the expansion of air weaponization in the early twentieth century. Yet while it is unrealistic to impede space-related technological advancement and constrain other states' weapons development, states can more feasibly manage deliberate geopolitical decisions as they navigate space-related strategic and security conditions.[61]

Although air weaponization and its rapid development prior to and during World War I was a means to political ends, it did not lead to the outbreak of war. World War I was a result of unstable politics, destabilizing events, miscalculations, and security dilemmas, all compounded by deliberate geopolitical choices leading up to active hostilities that locked states in an inevitable crisis.[62] Thus, despite an era of rapid and intense space weaponization, the international community must focus on taking deliberate geopolitical steps to avoid conflict escalation into space.

In spite of current levels of weaponization, space can remain relatively peaceful—an important objective for strategists and policymakers. To achieve this, the United

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[58] Joan Johnson-Freese, *Space Warfare in the 21st Century: Arming the Heavens* (New York: Routledge, 2017), 65–68.

[59] Stacey Solomone, *China's Strategy in Space* (New York: Springer Books, 2013), 58–59.

[60] O'Hanlon, *Neither Star Wars*, 26–27.

[61] Colin S. Gray, *American Military Space Policy: Information Systems, Weapon Systems and Arms Control* (Lanham, MD: University Press of America, 1984), 8.

[62] Kenneth N. Waltz, *Theory of International Politics*, 1st ed. (New York: Random House, 1979), 167; and Kier A. Lieber, "The New History of World War I and What It Means for International Relations Theory," *International Security* 32, no. 2 (Fall 2007): 156, 189–91.

States must take deliberate steps to minimize the chance of conflict breaking out as a result of such space weaponization, but also sufficiently prepare for conflict in space to deter geopolitical opportunities for the employment of space weapons. While many may argue these two actions will lead to an unnecessary and preventable self-fulfilling prophecy, such voices fail to understand the geopolitical realities of space.[63]

Despite decades of US national policy clearly stating space a vital national interest, potential adversaries have chosen to develop capabilities that threaten that vital national interest anyway. In addition, while transparency can help mitigate a potential security dilemma, no number of sensors can determine the intent of the increasing number of dual-use space systems and the potential threats they pose. Further, important elements of competitors' national and military strategies refute such transparency and openness, and instead embrace and leverage uncertainty as a strategic advantage.[64] ***Æ***

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[63] Matthew Burris, "Astroimpolitic: Organizing Outer Space by the Sword," *Strategic Studies Quarterly* 7, no. 3 (Fall 2013): 116.

[64] Everett C. Dolman, "New Frontiers, Old Realities," *Strategic Studies Quarterly* 6, no. 1 (Spring 2012): 83.

RESPONSIVENESS IS NOT OPERATIONAL

ALIGNING STRATEGY IN THE NEWEST SERVICE

Aaron T. Blore

The US Space Force is facing its greatest challenge: aligning new strategies with old. But when the new and old clash, as is actively happening in the tactically responsive space program, the difficulty in aligning acquisitions, tactics, operational readiness, and strategy becomes clear. This article highlights these challenges and offers solutions to enhance readiness in space with recommendations across all levels of war.

Formed mainly in reaction to adversaries such as China and Russia, the US Space Force has its roots in the US Air Force. Though this foundation dates back to the Cold War, it was primarily cemented between the early 1990s and when the Space Force was established in 2019, a time when US spacepower was largely uncontested. Contrary to the Air Force's beginnings in the throes of World War II, the Space Force has not yet been asked to prove itself in battle. Because of this, the service has been left to determine how to generate effects during protracted operations independent of experience.

With the lack of competition in the domain after the Cold War, US military space operations and now the US Space Force have had no need for robust spacepower theory, nor have there been experiences available upon which to base such theory. This is in contrast to the development of airpower, bathed in theory and experience and tested by adversaries competing to gain advantages provided by ever-capable aircraft with an assortment of roles.

In the early 2000s, the concept of operationally responsive space (ORS)—fast-tracking development and design to rapidly produce combat effects for the warfighter—and its later iterations were created to bridge the gap between theory and threat and to exercise the speed and capability of up-and-coming commercial partners.[1]

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[1] Arthur K. Cebrowski and John W. Raymond, "Operationally Responsive Space: A New Defense Business Model," *Parameters* 35, no. 2 (2005); and Scott C. Larrimore, *Operationally Responsive Space: A New Paradigm or Another False Start?*, research report for CADRE/AR, US Air Force, rep. no. AU/AFF/NNN/2007-04 (Maxwell AFB, AL: Air Force Fellows Program, April 2007).

Yet the concept of responsiveness, as a part of nascent spacepower theory, has bled into operational language and muddied the understanding of strategy, tactics, and requirements for the Space Force. But what is responsiveness? And how does responsiveness benefit a commander?

Current space doctrine defines responsiveness as the ability to react to changing requirements and meet combatant commander needs to maintain support. It is providing the "right support in the right place at the right time" and includes the ability to swiftly meet operational needs.[2] Yet this definition fundamentally varies from doctrine to doctrine and within the service itself. This confusion surrounding the notion of responsiveness and what it means is a case study of the misappropriation of terminology, the misalignment between doctrine, strategy and acquisitions, and an ignorance of history, that highlights why the US Space Force generally misunderstands how modern armed forces operate.

A critique of the tactically responsive space (TacRS) program—the initiative to develop and launch small satellites on short notice—reveals the challenges of defining the language of the domain that leads to doctrinal deficiencies and procurement requirements at the tactical, operational, and strategic levels. By increasing the focus on requirements, Space Force leaders can improve access to space and the sustainment of effects across a protracted war. The newness of the US Space Force provides an appropriate alibi for the charge of misalignment, but the challenges need to be addressed in order for the service to compete effectively.

History of Operationally Responsive Space

China's 2007 antisatellite test was a turning point for responsiveness, and US Congress members called for something new from space professionals. At the time, Arizona Senator Jon Kyl argued, "In a world where our space assets are likely to be threatened, operationally responsive space capabilities will allow us to quickly and affordably replace assets lost to anti-satellite attacks."[3] Thus, the operationally responsive space program was born.[4]

Having the flexibility of a swift conception-to-operation process could be a massive boon to a commander. Indeed, one initial proposal of such a capability, referenced above, was written in 2005 by a future US Space Force chief of space operations. Responsive space was deemed a "new business model" that allowed for bottom-up procurement of capability.[5] This contrasted the decades-old idea of the US government as the primary customer and purchaser of satellites from contractors.

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[2] US Space Force (USSF), *Sustainment*, Space Doctrine Publication (SDP) 4-0 (Washington, DC: USSF, 2023), 8, https://www.starcom.spaceforce.mil/.

[3] Larrimore, *Operationally Responsive Space*, 2.

[4] Courtney Albon, "US Space Force Plan for Rapid Satellite Launches May Finally Take Off," C4ISRNET, July 12, 2023, https://www.c4isrnet.com/.

[5] Cebrowski and Raymond, "Operationally Responsive Space," 68.

Over the years, the new ORS office launched many satellites with high speed—construction, storage, launch capability, and launch itself—and low cost. The ORS-5 satellite, launched in 2017, was lauded for its success in speed, cost, and capability.[6] The tactically responsive space initiative, the latest generation of responsiveness, maintains that heritage today. If conditions rapidly change, the TacRS program is the contract vehicle that would allow the service to fast-track a response to the combatant commander.

Tactically Responsive Space

The mission of the TacRS program is to launch a space-based, end-to-end capability within 24 hours of notice in response to a combatant commander's needs.[7] According to program office documentation, it involves understanding the tactical need in advance, building the satellite, placing it and maintaining it in storage, and then having the space-launch capability and capacity to take it out of storage and launch it quickly.[8] The mission of TacRS encompasses many aspects of space procurement in a fully aggregated package: acquisition, space launch and access, early testing, and operations.

Yet when discussed outside of the main program office, the clarity of the capability is diluted. The US Space Command commander has asserted that TacRS capability to "replenish" satellites will be critical to deterring China.[9] Congress has said the ability to "rapidly reconstitute degraded systems" is crucial.[10] Such comments run counter to the idea that the program will launch an end-to-end capability.

TacRS is a very small program—its budget in fiscal year 2023 was $50 million out of a total US Space Force budget of $26.3 billion.[11] Relative to its size, the program regularly features in conversations at the highest levels of civil and military space, including a recent mention in a Center for Strategic and International Studies conversation with the chief of space operations when discussing his theory of success, and in an opinion piece from the former administrator of the National Aeronautics and Space

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[6] SMC [Space and Missile Systems Center] Public Affairs Office, "SMC Sets New Standard of Success for Acquisition and Operations of SensorSat," press release, Air Force Space Command, October 9, 2019, https://www.afspc.af.mil/.

[7] Sandra Erwin, "Launch On Demand: If Satellites Are Shot Down, Will Space Force Be Ready to Restock?," *SpaceNews*, October 10, 2022, https://spacenews.com/.

[8] AFWERX Challenge, "Tactically Responsive Space Overview," May 2023, 2, https://afwerxchallenge.com/.

[9] Sandra Erwin, "USSPACECOM Supports Use of Responsive Launch to Deter China and Russia," *SpaceNews*, November 29, 2022, https://spacenews.com/.

[10] Sandra Erwin, "Lawmakers Ask House Appropriators to Add $50 Million for DoD 'Tactically Responsive Launch,' " *SpaceNews*, January 21, 2022, https://spacenews.com/.

[11] Marcia Smith, "Appropriators Boost FY 2023 Space Force Funding," SpacePolicyOnline, December 22, 2022, https://spacepolicyonline.com/.

Administration, Jim Bridenstine.[12] Yet the program's operational concept and the language used to support it show an immaturity within space warfighting.

The use of such terms as replenish and reconstitute by top commanders and civilian leaders discussing TacRS does not align with the program's stated goals; the word responsive, which differs in important ways from replenish and reconstitute, is part of the name of the program itself.[13] Yet, typically, these words are used when advocates discuss TacRS program capabilities, usage, or financing. In fact, these terms have a doctrinal definition that can completely change the nature of the capability depending on use. Such a disconnect is apparent across the service. While this article references TacRS in particular as a case study, its analysis can be applied to problems with terminology that are common across the Space Force, its programs, and its weapon systems.

Doctrinally Divergent?

The problem is not that senior leaders are using this terminology, but rather that the doctrine provides little clarity of communication on the purpose of a given mission. This clarity and nuance should help define alternative and differentiated mission sets for the Space Force if required. For example, a responsive program is different from a replenishment program. An augmentation of capability is different from a reconstitution effort. Each of these could be their own program. Yet each of these is not well defined for the space domain specifically. The misappropriation of terminology also highlights how US Space Force terminology differs from the broader Joint terminology, as revealed by areas of divergence between the space domain and its terrestrial counterparts.

The terms listed in table 1 are commonly used by the program office, senior leaders, Congress, and others to describe the space domain. Their definitions come from a variety of sources, and not just space doctrine. Their interplay highlights a deficiency in the understanding of space capability.

Just like every other warfighting domain, space struggles with unique needs and domain-specific challenges. The cost of attaining and changing orbits is extraordinarily expensive in both dollars and fuel. The cost of launch drove satellite design that required complete independence from terrestrial support mechanisms.[14] With no ability to refuel or upgrade hardware systems, the Space Force takes what it is given and operates within the constraints. The specific characteristics of the domain and

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[12] Center for Strategic and International Studies (CSIS), "Theory of Success: A Conversation with General Saltzman," CSIS, February 22, 2023, https://www.csis.org/; and Jim Bridenstine, "Tactically Responsive Space Strengthens America," *SpaceNews*, September 18, 2023, https://spacenews.com/.

[13] *Hearings on the National Defense Authorization Act for Fiscal Year 2023 and Oversight of Previously Authorized Programs*, 117th Cong. 64 (2022) (statements from Rep. Michael Waltz [R-FL] and General James H. Dickinson, commander, US Space Command), March 1, 2022; and "Keynote: Lt. Gen. Michael Guetlein," interview by Nathan Strout, C4ISRNET, April 20, 2022, video, 33:14, https://www.militarytimes.com/.

[14] Thomas D. Taverney, "Resilient, Disaggregated, and Mixed Constellations," Space Review, August 29, 2011, https://www.thespacereview.com/.

corresponding architecture choices make it difficult for Guardians to directly apply Joint terminology, but not for lack of effort.

Table 1. 'Re'wording the US Space Force: The 'Re'apportionment of Definitions for the Domain

Responsive	The ability to react to changing requirements and meet the needs to maintain support. It is providing the right support in the right place at the right time. It includes the ability to meet operational needs rapidly.[15]
Reconstitute	Action to restore units to a desired level of combat effectiveness commensurate with mission requirements and available resources. It transcends normal day-to-day force sustainment actions. Yet it uses existing systems and units to do so. No resources exist to solely perform reconstitution.[16]
Replenishment	Generally defined across multiple instances as operations required to transfer personnel, supplies, or fuel.[17]
Resiliency	The ability to withstand, fight through, and recover quickly from disruption.[18]
Readiness	The ability of the military forces to fight and meet the demands of assigned missions.[19]
Reserve Satellite (new)	Spacecraft that have been accumulated in excess of immediate needs for active spacecraft and are retained in the inventory against possible future needs.[20]

Initial attempts at Space Force doctrine have either wholesale applied doctrine from the Air Force or combined terms that further muddle the issue. For example, in the capstone Space Force doctrine publication *Spacepower*, space launch is associated with both space mobility and space logistics. The publication makes no delineation between the two terms, paired together under the acronym SML.[21] The newest Space Force doctrine, *Operations*, Space Doctrine Publication (SDP) 3-0, references the capstone document's definition but reformulates the acronym to SAML with the addition of space access.

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[15] USSF, *Sustainment*, 8.

[16] Headquarters, Department of the Army (HQDA), *Reconstitution*, Field Manual 100-9 (Washington, DC: HQDA, January 13, 1992) (no longer active); and John M. Menter, "The Fallacy and Myth of Reconstitution," US Army (website), March 28, 2019, https://www.army.mil/.

[17] Chairman of the Joint Chiefs of Staff (CJCS), *Joint Logistics*, Joint Publication (JP) 4-0, (Washington, DC: CJCS, July 20, 2023).

[18] Department of Defense (DoD), *2022 National Defense Strategy of the United States of America* (Washington, DC: DoD, October 2022), 16, https://media.defense.gov/; and Frank Kendall, *Comprehensive Strategy of the Air Force* (Washington, DC: Department of the Air Force [DAF], August 15, 2023), https://www.spaceforce.mil/.

[19] CJCS, *DoD Dictionary of Military and Associated Terms*, JP 1-02 (Washington, DC: CJCS, 2007), 451, https://dcsg9.army.mil/.

[20] Author's definition; see CJCS, *DOD Dictionary*, s. v. "reserve satellite," 464.

[21] USSF, *Spacepower*, Space Capstone Publication (Washington, DC: USSF, 2020), 37, https://media.defense.gov/.

SDP 3-0 does define the terms separately. Mobility is parenthetically defined as movement and maneuver and "includes post-launch transport of space vehicles between orbits, within orbits, and augmented maneuvering to enhance mission effectiveness or maneuvering related to reconstitution, operational degradation or loss, and end-of-life actions." Logistics "may include spacecraft servicing, disposition, debris management capabilities, refueling, and in-space component installation." Yet space launch continues to remain associated with both.[22]

Traditionally, the Department of Defense acquires weapon systems, not logistics programs. Setting requirements and developing programs for logistics is putting the cart before the horse. Other domains have initial logistics requirements, such as ports in the maritime domain or troop transport for the Army. Likewise, assets such as cargo aircraft provide key logistics and mobility capabilities. If the TacRS program is an attempt to operationalize space launch, it seems to be missing the focus of the mission. If instead space launch is more of a mobility capability, such as a C-17, then it needs to be operationalized like a weapon system with the requirements and US Space Force ownership to match. But mobility and access are not the only victims of reinvention.

Responsiveness made its way into Joint Publication (JP) 3-14, *Space Operations*, an operational doctrine, as well as SDP 4-0, a sustainment doctrine.[23] Space doctrine has more correctly placed responsiveness as one of the nine "principles of sustainment."[24] This doctrine mimics the language in JP 4-0, *Joint Logistics*, which states "responsiveness is providing the right capability when and where it is needed" but changes the definition. Space responsiveness reacts "to changing requirements"; Joint responsiveness simply provides "the right capability."[25]

While the intent is similar, the definitions are fundamentally different. Between 2020 and 2023, Joint space doctrine replaced responsiveness with agility. In 2020, responsiveness was defined assuch: "Space operations provide the ability to surge some types of capabilities, such as communications or ISR, on much faster timescales than ground-based or airborne capabilities. As priorities change, some space resources can be rapidly reallocated to the areas where they are needed most."[26] In 2023, agility is defined as such: "Space operations enhance joint capabilities, such as communications or ISR, with greater speed, reach, and persistence compared to ground-based or airborne modalities. As priorities change, some space capabilities can be reallocated to the areas where they are needed." [27]

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[22] USSF, *Operations*, SDP 3-0 (Washington, DC: USSF, 2023), 52, 36, https://www.starcom.spaceforce.mil/; and see Theresa Hitchens, "Enhancing 'Lethality': First Space Force 'Operations' Doctrine Cements Role within Joint Force," Breaking Defense, August 3, 2023, https://breakingdefense.com/.

[23] CJCS, *Space Operations*, JP 3-14 (Washington, DC: CJCS, 2020), I-4, https://www.jcs.mil/.

[24] USSF, *Sustainment*, 8.

[25] USSF; and CJCS, *Joint Logistics*, x.

[26] CJCS, *Space Operations*, I-4.

[27] CJCS, *Joint Space Operations*, JP 3-14 (Washington, DC: CJCS, 2023), I-5–I-6.

The tension here is that responsiveness can be defined multiple ways. One way is mission related: troops in contact prefer higher responsiveness from close air support missions. A highly responsive space capability is likely one already on orbit and the timeliness is derived from a satellite's persistence relative to another domain. The other definition is the responsiveness of acquisition and logistics. A military without knowledge of the threat, or in a war of attrition, prefers responsiveness from acquisitions and logistics. The TacRS conversation seems to drift between the two.

Language used by TacRS supporters such as reconstitution and replenishment are other examples of this confusion. Both terms have foundations in logistics and a history to match. The Joint logistics enterprise—the network of key global logistics providers that support the Joint Force's needs—has an operating framework that clearly outlines logistical objectives at the three classic levels of war. Within the 176-page Joint doctrine document, reconstitution is not a guiding principle and is rarely mentioned.[28] In space doctrine, reconstitution is specifically defined as "the restoration of functionality to an acceptable level for a particular mission, operation, or contingency after severe degradation" and includes both space- and ground-based equipment and personnel.[29]

Replenishment, on the other hand, is mentioned but specifically aligned with the transfer of fuel, food, supplies, and personnel between ships.[30] A replenishment satellite to a Sailor may be more akin to an "oiler satellite" that refuels others instead of an end-to-end responsive capability. In space doctrine, replenishment is casually referenced similarly to that of ships in terms of consumables and expendables on spacecraft. But the tepidness of the definition as part of a larger discussion on sustainment trivializes the difficulty of on-orbit refueling. An authoritative push for on-orbit replenishment of satellites would go a long way to providing clarity of meaning.

Misalignment with Joint doctrine can cause difficulty in advocating for the proper requirements at all levels and when integrating across services. Differences between Joint- and service-level doctrine is not unheard of. Yet the uniqueness of the Space Force should drive some reflection upon whether reinventing the wheel is a good idea. Indeed, this reflection should come now, before finalizing doctrine. How these divergences play out at the tactical, operational, and strategic levels must be explored.

Tactical Deficiencies

The name of the TacRS program, Tactically Responsive, implies a timing and tempo that would assist with a tactical timeline. But whose tactical timeline? Though the logic behind the name of the program is missing, the importance of understanding tactical timelines for space is not. In the span of 24 hours, the currently reported mission timeline, many tactical operations could occur. In low Earth orbit, satellites

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[28] CJCS, *Joint Logistics*.

[29] USSF, *Sustainment*, 16.

[30] CJCS, *Joint Logistics*.

encircle the Earth upwards of 15 times per day. Depending on the orbit, that could mean multiple daily targeting opportunities for the adversary.[31]

If US Space Command is supporting terrestrial missions with a now-defeated satellite, the responsiveness of 24 hours may be well past a tactical commander's needs, depending on the capability provided. On the other hand, the timeline may be sufficient for a Space Command mission alone. To that end, even industry believes this logic, pushing the Space Force to "strengthen the concept of operations."[32] Industry experts seem to understand they are being asked for 24-hour launches, yet do not understand how the Space Force intends to use the capability. For a domain that largely supports terrestrial forces, the nuances in language matter.

Misunderstanding tactical timelines is not the only tactical deficiency highlighted by the TacRS program. An analysis of the program also reveals the force's deficient tactical capability. Inherent in the desire for responsiveness is the implication that the current satellites in orbit are insufficient for the United States to survive a significant attack.

As discussed above, today's Space Force satellites were developed in an era of US hegemonic spacepower with no adversary. As a result, defensive capability is likely deficient. Yet setting responsiveness as a goal not only is a tacit acknowledgement of the deficiency, but also points to an insidious undercurrent that elevates defeat instead of success. The new comprehensive strategy for the Space Force seems to get this right by separating resiliency and responsive sustainment into two implications for the Space Force.[33] The focus on defensiveness would lessen the requirement for responsiveness. A level of responsiveness has always been required across all domains. But if defensive capabilities are required from the initial design, less reactive responsiveness is required at the operational level.

Operational Responsiveness

Operationally, the underlying assumption of responsiveness is the need to adapt to new or changing combatant commander requirements. At the early outset of the program, the threat situation in the space domain was new and unknown. Why spend dollars on a big budget space program if the threat is unknown? That has changed since 2007; the threat is now known and the principles of winning on orbit are demonstrated three times per year at the services' Space Flag exercise. Organizationally, the new service exists to help define and advocate for the requirements that have emerged since the changes in the domain since 2007.

Though the responsiveness of a commander is critical, typically, operational responsiveness has not been the domain of military procurement. Responsiveness

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[31] US Defense Intelligence Agency (DIA), *2022 Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion* (Washington, DC: DIA, 2022), https://www.dia.mil/.

[32] Sandra Erwin, "Space Force Lays Out Timeline for 2023 Rapid Response Launch Experiment," *SpaceNews*, November 6, 2022, https://spacenews.com/.

[33] Kendall, *Comprehensive Strategy*, 6.

instead has been built historically through tactical and operational readiness.[34] Responsiveness is created by ensuring the combat capability can achieve the desired effect and is ready to execute operations on a specified timeline.

For example, a Special Forces unit with high readiness is typically able to deploy faster than a larger Army combat unit, therefore achieving high responsiveness. Speed and time are the components: a fixed-wing close air support aircraft may be able to support troops in contact faster than a rotary-wing aircraft covering the same distance, yet if the rotary-wing aircraft is nearby, it takes the objective. To an earlier point, a force already in the area typically provides the fastest response.[35]

The desired effect provides different opportunities for readiness objectives for the Space Force. Instead of an end-to-end solution from launch to orbital operations, what if the requirement was an ability to match any orbit within 24 hours? The same effect could be achieved at the satellite level and would promote changes to maneuver and fuel capabilities, both of which could drive increases in satellite capability across the force. Likewise, an inability to achieve the 24-hour timeline would factor into a readiness calculation by a commander. If the commander's requirement is purely responsiveness, defining what responsiveness looks like in terms of readiness may achieve a better outcome.

Likewise, the earlier confusion of reconstitution highlights more deficiencies at the operational level. When the Army used reconstitution, it implied available forces to reconstitute with, either from combining broken units or bringing forward reserve forces. For example, World War II and the Korean War both saw Army reconstitution with "divisions and regimental combat teams rotated off of the front lines to absorb and train replacements."[36] The practice was largely enabled by the draft and an "impressive industrial supply complex capable of producing any required military equipment."[37]

While SDP 4-0 covers reconstitution, the requirements for such highlight the complexities of the task. Reconstitution requires "planning and lead-up operations to build, integrate, and deliver a payload or payloads to orbit."[38] That is effectively the entire design cycle for a satellite minus operations and end-of-life. Is TacRS operationalizing acquisitions? The TacRS program does seem to meet the doctrinal intent with the reserve satellite on the ground, but that drives the discussion toward the physical placement of reserve forces.

While the elements may translate to Space Force satellites, a more similar analogy would be that of a ship or an aircraft. Neither of these platforms use reconstitution; they use reallocation instead. As a thought experiment, how does a new ship or aircraft

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[34] Stacie L. Pettyjohn, *The Demand for Responsiveness in Past U.S. Military Operations* (Santa Monica, CA: RAND Corporation, 2021), https://www.rand.org/.

[35] Pettyjohn.

[36] Menter, *Fallacy and Myth*.

[37] Menter.

[38] USSF, *Sustainment*, 16.

arrive in theater if one is destroyed in combat? Simply, the service reallocates forces from either reserve forces or forces in another theater. Is TacRS then reallocating satellites from a terrestrial theater to the heavenly theater with space launch as the mobility mechanism? If yes, is not then Earth the "port" of a satellite since it cannot operate in that domain? Given a satellite does not operate terrestrially, a bird in orbit is worth two in the bush.

Unfortunately, reallocation within the domain is not any easier. If all satellites in orbit are already in the area of responsibility for the combatant command, confusion mounts as to who owns and has control of the satellite: the service or the combatant command. Force ratios, allocation, and design are not fully formulated within the space domain and deserve further consideration and development. TacRS just happens to be the contract vehicle that highlights this deficiency. The operational challenges for the most junior service continue to pile up.

Strategic Focus

At the strategic level, TacRS highlights a lack of focus between strategy, combatant commander requirements, and a space-industrial base output. Chief of Space Operations General B. Chance Saltzman's theory of success, referred to as Competitive Endurance, offers an early strategic direction that provides the required focus. The main tenets of this theory include avoiding operational surprise, denying first-mover advantage, and counterspace campaigning.[39] The first two of these, while defensive in nature, are inherently proactive. Operational surprise in the domain is prevented through space domain awareness, or intelligence of the activities in and through the domain. Denial of first-mover advantage focuses on resilience to win through either active or passive defense. Responsiveness and reconstitution focus on reactive defense after deterrence has failed—counterspace campaigning.

The defensive bent from TacRS is a responsive model that strives for dominance via an anti-attrition style of war and overwhelming logistics. In attrition warfare, the objective is to outlast the enemy through the sequential destruction of their forces and to prevent the same from happening to one's own forces. Maneuver warfare, attrition warfare's opposite, uses initiative and rapid movement of forces for success.[40]

While there are more styles of war, with the TacRS program and other new programs from the Rapid Capabilities Office and Space Development Agency, the Space Force is attempting to build toward surviving an attrition war through resilience. Yet within the first Space capstone document, maneuver warfare is the focus of discussion.[41] The doctrinal focus on maneuver is unsurprising; most modern and democratic militaries have focused on maneuver warfare for decades. But the efforts mentioned above seem to focus on outlasting the enemy through overwhelming logistical superiority.

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[39] See CSIS, "Theory of Success."

[40] Brent L. Peterson, "The Factors That Influence Air Strategy: How Do Leaders Choose Air Strategy?" (master's thesis, School of Advanced Air and Space Studies, Air University, June 2019), https://apps.dtic.mil/.

[41] USSF, *Spacepower.*

If the service is leaning toward resiliency as the focus, the Space capstone document may already be out-of-date. If the service still desires maneuver warfare-based weapon systems, programs with a maneuver focus have yet to be publicized. Doctrine provides the "foundational and authoritative purpose and identity of a military force."[42] The service needs both the ability to survive the onslaught of the enemy and a force able to fight and win.

The problem of permanence on orbit further plagues the issue. The combined assumptions of resiliency, responsiveness, and reconstitution run counter to the problem of space debris. The theory of success touches on the problem from the side of the offense in that "space superiority must not create hazardous debris that jeopardizes the Joint Force's access to vital space capabilities."[43] But resiliency could create that exact debris problem on defense without ever giving the United States the offensive opportunity in the first place. Space-debris permanence creates a tug-of-war between offense and defense in space that still lacks resolution.

Overwhelming logistics helped the United States win two world wars, so the pursuit is worthy. Unfortunately, as it stands right now, the state of the space industrial base and supply chain may not support a simple wartime effort. Over the past 25 years, the Department of Defense has launched about 75 missions, or about three per year.[44] The commercial side is not significantly different. Assuming a wartime effort includes both commercial and government resources, production may support six satellites per year. Is that enough to overwhelm the adversary? Likely not. In fact, that recognition drove changes to procurement and the Space Development Agency's plan in 2023 to launch a thousand microsatellites for resiliency purposes.[45]

This highlights another potential issue facing the newly formed service: TacRS highlights a lack of clarity regarding combatant commander requirements. The TacRS program is a "broader effort by the US Space Force to accelerate the timeline for deploying payloads to orbit."[46] In a picture-perfect world, the combatant commander would understand the adversary, the tactical skill of friendly forces, force ratios and allocation, and the state of the space industrial base. Based on this, they would ask for precisely what is needed to win the war effort.

In reality, fundamental analyses of requirements based on strategic outcomes could drive satellite production goals. A broader effort of accelerated timelines should not be the focus of a single program but instead the result of greater demand signaled

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[42] Kenneth Grosselin, "A Culture of Military Spacepower," *Air and Space Power Journal* 34, no. 1 (March 23, 2020): 79.

[43] CSIS, "Theory of Success."

[44] Eric Berger, "With Reusable Rockets on the Rise, Air Force Changes EELV Program Name," Ars Technica, March 4, 2019, https://arstechnica.com/.

[45] Ramin Skibba, "The Space Force Is Launching Its Own Swarm of Tiny Satellites," Wired, August 14, 2023, https://www.wired.com/.

[46] Sandra Erwin, "Firefly, Millennium Space Selected for U.S. Space Force Rapid-Launch Demonstration," *SpaceNews*, October 1, 2022, https://spacenews.com/.

collectively by the needs of combatant commands. Even still, accelerated timelines are not without merit.

Recommendations

A Place in the New US Space Force Mission

The first recommendation may solve the strategic confusion. The Space Force recently published a new mission for the service: "Secure our Nation's interests in, from, and to space." This gives a TacRS-like capability a new opportunity for mission relevance. Per the previous discussion, responsiveness should not be the program's ultimate goal. Instead, the program should focus on the interest of having access to space. This means divorcing access to space from the goal of tactical responsiveness. In order to receive capability in and from space, the nation must first get to space. Focusing the program on one objective could provide a long-term competitive advantage.

Saltzman's first note to Guardians after assuming his role as chief of space operations includes a line that could provide nuance: "The Space Force must field combat-ready forces prepared to outcompete rivals, deter aggressors, and defeat enemies."[47] A responsive capability may help outcompete rivals, but not necessarily deter or defeat others. To extend the maritime analogy mentioned earlier: access to the sea is strategically important, but the capability it provides is the interest behind such access.

Prioritize War-Winning Effects

The second recommendation is one of strategic and industrial base requirements. From a strategic perspective, the Space Force needs to focus its efforts on war-winning effects first, then the supply chain as support next. Proposing the idea of rapidly launching replenishment satellites is deciding that the logistics arm of the Space Force should be developed first. Likewise, resilient and defenseless satellites are built for sacrifice instead of winning.

To ensure operational effectiveness, the development of combat capabilities should take precedence over supply-chain establishment, analogous to the prioritization of fighter and bomber equivalents over a tanker. US Space Command should advocate for requirements that drive toward decisive victory conditions within the area of operations, reinforcing an uncompromising operational posture.

This requires a newfound focus on understanding the mission, then using the mission to drive the requirement through the Joint requirements process. This means identifying the need, codifying it in bureaucracy, and potentially establishing a new program. While that may not be responsive, the process exists to tie missions to tasks to requirements.

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[47] B. Chance Saltzman, "LOE 1 - Fielding Combat Ready Forces," January 18, 2023, https://www.spaceforce.mil/.

Focus on Operational Readiness

The third recommendation tightens the loop between capability development and operational readiness consideration. Though the theme of connecting operations and procurement is discussed at length in strategic documents, the specifics on what that looks like are typically inadequate.[48] The Space Force needs to develop requirements that win all levels of war.

Tactically, satellites should be able to defend themselves through any known defensive options. Operationally, force ratios need to be understood, put into requirements, and driven toward capability and force design. Changing the thinking to focus on operations and readiness could enhance the space industrial base at a level that could support a 24-hour launch. In other words, the Space Force should seek to buy highly capable and readied satellites first, then conduct launches that get them to orbit, not combine the two missions into one.

Operationally responsive space was viewed at the time as a bridge model that would create demand for small and nontailored satellite capabilities owned by operational and tactical commanders. While the bridge still has value, delineation between acquisitions and tactical responsiveness is critical. And if the goal is tactical timeliness, a clear readiness posture should be a requirement. In practice, it may be more effective to understand the domain and its readiness requirements and put a satellite into space ahead of need.

Understand the Battlespace Holistically

A fourth recommendation combines operational and tactical needs focused on understanding the battlespace. Air-refueling capability requirements can be traced back to operations: How many air refuelers and how much fuel does the nation need to cross the Pacific and win a war? The analogy is used to drive home the understanding that the battlespace was understood before the requirement was developed. The US Space Force and Space Command need similar metrics for either space launch or satellites.

Not only are the metrics based in logistics at the operational level, but understanding the cost of delta-v at the tactical level, requirements of maneuver, and potential loss rates could inform this recommendation. Likewise, the service needs to retain assets for test, training, and reserve purposes. Retaining assets increases the service's ability to provide responsiveness via reallocation to the combatant commander.

Transform Space Access and Sustainment

As a fifth and final recommendation, the Space Force should radically change its space access and sustainment approach. The recognition and study of the vast literature on mobility and logistics is a logical place to start. Additionally, this involves taking that knowledge and not just holistically transitioning it to the space domain

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[48] DAF, *U.S. Air Force 2030 Science and Technology Strategy* (Washington, DC: USAF, April 2019), https://www.af.mil/.

but leveraging it to create novel applications of the knowledge within the domain. Seemingly radical ideas such as using cislunar space as a satellite reserve location places satellites out of current threat regions while maintaining a higher readiness than a terrestrial launched option.[49]

While the Space Force has begun to publish doctrine, committing to the wrong doctrine is worse than committing to no doctrine at all. The authoritative nature of doctrine makes it a primary source of knowledge and needs to rapidly iterate along with the newest service.

The combination of these recommendations could provide a new model for acquiring the appropriate weapon systems. Airframes or ships combine to create a lethal force through the specialization of weapon systems and knowledge of the domain. Fighters, bombers, and air refuelers work together to combine effects from the air. One without the other creates opportunity for an adversary.

Conclusion

TacRS is an impressive capability, and many great Americans work on the programs. And yet, the challenges discussed in this article require solutions. The analysis underscores the imperative for the US Space Force to address key strategic and operational challenges to effectively prevail in future space conflicts. The service needs to redefine its mission to prioritize winning through war-winning effects, tighten the loop between capability development and operations, comprehensively understand the battlespace, and embrace transformative approaches to space access and sustainment. These five recommendations, grounded in military theory and strategic insights, provide a framework for enhancing the Space Force's readiness.

As we navigate the complexities of the space domain, implementing these recommendations will be crucial in ensuring the service will meet future challenges head on and emerge triumphant. Responsiveness still has its place in acquisitions to be faster and more agile to the changing character of war. For the US Space Force to win the first war in space, it first needs the capabilities to do so. The question the Space Force needs to ask is, Is our goal to win or to be responsive to failure? **Æ**

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[49] Alexander Urban, "Development of Minimum Delta-V Trajectories to Service Geo Assets from Cislunar Space" (master's thesis, Air Force Institute of Technology, March 2022), https://scholar.afit.edu/.

THE COST OF SPACE SYSTEM CLASSIFICATION

Christopher C. James

Overclassification, contracting professionals' lack of access to contemporary automated information technology systems, and ongoing barriers to entry for small businesses are driving sacrifices to US Space Force system procurement speed, cost, innovation, and international partnerships. By adapting existing regulations, leveraging commercial machine learning, and applying minimal financial resources, the US Space Force can overcome the space acquisition challenges related to overclassification, counterproductive barriers to entry, and antiquated classified systems and regulations.

In order to defend US interests, specific classification levels protect national secrets and associated space program acquisitions. Yet, the restrictive nature of those protections ultimately shapes US Space Force business decisions that can result in the sacrifice of procurement speed, cost, innovation, and partnerships with Allies.

The operational impacts of classification and overclassification are generally well known, as General John E. Hyten, then deputy chairman of the Joint Chiefs of Staff, emphasized in 2020: "You can't deter people if everything you have is in the black."[1] In contrast, the acquisition process runs behind the scenes as a support function and requires advocacy at the original classification authority (OCA) level to ensure the classification impacts on speed, cost, and technical solutions are being equally weighed with the operational need to protect national secrets and certain capabilities. For programs that still require classification, changes to policy, regulation, technology, and government incentives will offer solutions to the issues associated with speed, cost, and access to a broad industry base.

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[1] Robert Fahs, "Gen. Hyten Finds Over Classification of Space Information Undermines National Security, Promises Reform," *Transforming Classification* (blog), Public Interest Declassification Board, National Archives and Records Administration (NARA), December 1, 2020, https://transformingclassification.blogs.archives.gov/.

Introduction

Specific to the acquisition of space systems—ground, link, and on-orbit segments—a portion of the US Space Force portfolio is subject to a varied degree of classification based on the capability or mission assigned to a given platform. In line with maintaining national security secrets and consistent with Department of Defense practices, it is assumed that the most capable US Space Force systems are currently protected through the highest forms of classification, including Top Secret and Special Access Program (SAP) controls. While the operational need to classify certain military capabilities may be understood by American decisionmakers and the public at large, there is little published evidence that reflects an awareness of the negative impacts from classification on space system acquisitions.

The decision to classify a particular program or capability initially happens at the highest echelons of the government, through the original classification authority of the president, vice president, and their delegated agency heads.[2] Within DoD space procurement, OCA has been delegated down to eight separate agency heads who have further delegated collateral authorities down across several headquarter components. Space program classification decisions made at the OCA level—from the president to headquarter components—have a direct impact on fiscal accountability and how space systems are acquired.

Space acquisitions are overseen by integrated product teams, consisting of technical experts, requirement owners, financial staff, and contracting professionals. For unclassified acquisitions, the teams procure and sustain space systems with typically few coordination efforts outside of their respective teams.[3] Unclassified acquisitions are subject to high levels of congressional scrutiny and face potential termination in the case of cost overruns that violate the Nunn-McCurdy Amendment.[4]

For classified programs, the bureaucratic scope of procurements expands dramatically. Depending on the classification level, the integrated product team must coordinate and seek regular approvals from multiple organizations, including but not limited to the relevant program security office, the Defense Counterintelligence and Security Agency, and the Office of Special Investigations.[5] With regard to oversight, classified appropriated funds are not subject to the cost controls that impact unclassified portfolios.[6]

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[2] Exec. Order No. 13526, 75 Fed. Reg. 707 (January 5, 2010).

[3] Rob Creekmore, Marie Muscella, and Craig Petrun, *Integrated Project Team (IPT) Start-up Guide* (Bedford, MA: MITRE Corporation, 2008), https://www.mitre.org/.

[4] Alan Kent Gideon, "An Empirical Examination of Major Department of Defense Acquisition Program Cost Overruns and Its Application to Reference Class Forecasting" (PhD dissertation, George Washington University, 2015).

[5] Space Systems Contracting Officer, "Competition in Classified Contracting Survey," Schriever Space Scholars, Montgomery, AL, December 14, 2022.

[6] Gideon, "Empirical Examination," 14.

In addition, the infrastructure required to meet mandatory National Industrial Security Program requirements creates high barriers to entry for new defense contractors. Depending on the geographic location, construction or modular installation of a sensitive compartmented information facility (SCIF) can cost up to two times the price of standard commercial buildings utilized by the federal government, and that does not account for the cost of approved storage containers, specialized communication equipment, and personnel security clearances.[7] The National Industrial Security Program certification process is time-intensive, putting new entrants in a position to carry operations and facilities costs for long durations without a guarantee of earning business from the government.[8] The capital investments coupled with layers of bureaucratic processes that have compounded over decades have created a small pool of capable defense industry contractors; this inherently stifles innovation and nontraditional approaches.

Lacking the organic capability to produce space assets, all US Space Force systems rely on services and supplies that must be procured through the contracting process. Once classification is introduced, every aspect of an acquisition from the initial market research to the final negotiated agreement adds another layer of complexity. Engagement with industry partners becomes process driven and requirement owners are forced to plan for and contend with classified infrastructure designs and requirements.

Since the effects of classification on the space system acquisition process are the result of government regulations and policy, decisionmakers are in a position to make foundational changes through those same mandates. Decisionmakers with OCA authority need to be advised by practitioners who understand the acquisition implications of classifying a program or mission.

Background: Military Contracting

In 1984, lacking a standardized system of procurement throughout the executive branch of government, Congress passed the Competition in Contracting Act (CICA) to establish a fair and transparent contract award process.[9] The establishment of CICA formed the base of the Federal Acquisition Regulation (FAR), Defense FAR (DFAR), and Air Force FAR (AFFAR), which govern the entirety of the contracting process for the Department of the Air Force.[10]

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[7] Modular Management Group, Inc. (MMG), *GSA Schedule 47QSMD20R0001: GSA Contract GA-07F-0222X, Authorized Federal Supply Schedule Price List* (Fort Worth, TX: MMG, 2022), https://www.gsaadvantage.gov/; and Government Accountability Office (GAO), "Federal Real Property, Measuring Actual Office Space Costs Would Provide More Accurate Information," report to The Honorable Peter DeFazio, US House of Representatives, GAO-20-130 (Washington, DC: GAO, December 10, 2019), https://www.gao.gov/.

[8] Office of the Under Secretary of Defense for Intelligence and Security, *National Industrial Security Program*, Department of Defense (DoD) Instruction 5220.31 (Washington, DC: DoD, 2023), https://www.esd.whs.mil/.

[9] Competition in Contracting Act of 1984, H. R. 5184, 98th Cong. (1984), https://www.congress.gov/.

[10] Competition in Contracting Act, 3.

The FAR and its supplements established a procurement system requiring contracting officers to leverage commercial markets through the use of full and open competition and ensure contract award criteria are concise and not overly restrictive. To do this, unclassified procurements leverage automation through robust solicitation, award, and contract administration web-based platforms. The use of automated systems and regulations that favor competition creates efficiencies in execution that classified contracts struggle to achieve.

To broaden the number of companies that possess national security skill sets and access nontraditional defense contractors, or tech start-ups, the Department of Defense has embraced the use of Other Transaction authorities. Originating from authorities given to the National Aeronautics and Space Administration (NASA) in 1958, OT authorities were granted to the services in 1994 and are a non-FAR-based method of contracting for research, prototypes, and production that leverage economies of scale and reduce the burden of government regulatory overhead.[11] Typically, OT authorities are sourced from groups of business consortiums that include companies of all sizes that are allowed to compete for government business just like the FAR-based process.

These authorities level the playing field for new defense contractors in two ways. They lower barriers to entry by avoiding FAR-based statutes/regulations that impose significant costs, and they leverage commercial industry practices such as contracting from system prototype through initial production.

Industry Consolidation

Since 1990, the defense industrial base has undergone a substantial consolidation including among its prime aerospace contractors, shrinking the competitive landscape for the Space Force from 51 to 5, with satellite suppliers being reduced from 8 to 4.[12] The effects of consolidation on the competition can be felt across the entire Department of the Air Force: fixed-wing aircraft suppliers have been reduced from 8 to 3, and 90 percent of all the missiles procured are provided by only three sources.[13]

Several factors have been attributed to the consolidation of the defense industrial base: DoD budget reductions since 1985, low interest rates that increase access to capital, and the time-intensive process of major systems' development.[14] In addition, the technical complexity of space-based acquisitions makes them susceptible to "vendor

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[11] Kristine Kassekert, "This Is Not Your Father's Oldsmobile or Other Transaction," DAU [Defense Acquisition University], August 14, 2023, https://www.dau.edu/; and Office of the Under Secretary of Defense for Acquisition and Sustainment (OUSD[A&S]), *Other Transactions Guide*, 2.0 (Washington, DC: DoD, July 2023), app. B, 4–5, https://www.acq.osd.mil/.

[12] Heidi M. Peters, "Defense Primer: Department of Defense Contractors," In Focus 10600 (Washington, DC: Congressional Research Service [CRS], updated January 17, 2023), https://crsreports.congress.gov/.

[13] OUSD(A&S), *State of Competition within the Defense Industrial Base* (Washington, DC: DoD, February 2022), https://media.defense.gov/.

[14] OUSD(A&S), 5.

lock," or sole-source contracts, as well as issues relating to intellectual property and data rights. Due to infrastructure and personnel clearance requirements, classification further restricts the available pool of businesses to contract with. More broadly, in fiscal year 2021, the Federal Data Procurement System–Next Generation reported a total competition rate of 52 percent across a total of $375 billion spent on DoD contracts.[15]

Role of Contracting Professionals

At its core, the military contracting profession is responsible for procuring services, supplies, and capabilities that cannot be provided by the services organically. Once earned, a purchasing warrant is issued to a DoD contracting officer, giving that person the legal authority to negotiate and create binding agreements (contracts) on behalf of the US government.[16]

Aside from the execution of negotiated agreements, contracting professionals lead the operational contract support process. As defined in Joint Publication 4-10, *Operational Contract Support*, this process is focused on the planning and processes that effectively integrate contracted support into military contingency operations.[17] As recent as 2017, during Operation Inherent Resolve, it was estimated the United States had approximately 5,000 active-duty members in Iraq who were supported by contracted personnel at a ratio of seven contractors for every one active-duty member.[18] For the Joint Force, contracted capabilities have become an integral part of all military operations by enabling uniformed members to focus on their warfighting skill sets and the contingency missions at hand.

Within US Space Force space systems acquisitions, the contracting officer is charged to employ the tenets of operational contract support and use their warrant authority to secure technical capabilities at a price that is fair and reasonable to the government. As the business leader of the integrated product team, the contracting officer plays a vital role in crafting the acquisition strategy and serves as the lead integrator between the government and the commercial industry.

Background: Security Classification

In 1940, President Franklin Roosevelt issued the first executive order on the conditions and procedures for the classification of government material.[19] In the years since, additional executive orders, laws, and DoD manuals have been published in an

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[15] OUSD(A&S), 3.

[16] Federal Acquisition Regulation, "1.602-1 Authority," Acquisition.gov, 2023, https://www.acquisition.gov/.

[17] Chairman of the Joint Chiefs of Staff (CJCS), *Operational Contract Support*, Joint Publication (JP) 4-10 (Washington, DC: CJCS, March 4, 2019), https://www.jcs.mil/.

[18] Jeffrey Martini et al., *Operation Inherent Resolve: U.S. Ground Force Contributions* (Santa Monica, CA: RAND Corporation, 2022), https://doi.org/.

[19] Kevin R. Kosar, *Security Classification Policy and Procedure: E.O. 12958, as Amended* (Washington, DC: CRS, November 3, 2009), https://apps.dtic.mil/.

attempt to further clarify and streamline the classification process. The ability to classify government information rests with the president and vice president; however, this original classification authority responsibility may be delegated down to the heads of select federal agencies and limited personnel under their supervision.[20]

The relevant OCA may classify information at varied levels based on its unauthorized disclosure, potentially causing grave damage, serious damage, or damage to national security (Top Secret, Secret, and Confidential, respectively).[21] Additional controls like Special Access Program or No Foreign (NOFORN) further compartmentalize and restrict information to smaller groups of personnel. The classification decisions made by the OCA (may) endure for decades and, among other outcomes, ultimately define how space systems are acquired.

Problem of Overclassification

The question of what should be classified and to what level is subjective and often leads to overclassification. Executive Order 13526 states that for information to be classified, it must fall into one of eight categories, such as "vulnerabilities or capabilities of systems relating to national security."[22] In 2003, the National Archives reported that 14 million documents were classified across 3,978 authorized federal officials, resulting in an 8 percent increase from the year before.[23] In addition, it is estimated that 90 percent of those 14 million documents were overclassified in some way.[24]

Derivative Classification

The sheer volume of classified documents is due in large part to derivative classification authority that allows cleared DoD personnel to generate classified information that is derived from OCA source material and applicable security classification guides/program security guides (SCGs/PSGs) that further detail how information should be handled.[25] According to current estimates, the federal government generates millions of classified documents every year through the use of derivative classification authorities.[26]

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20. "Basic Laws and Authorities," NARA (website), August 15, 2016, https://www.archives.gov/.

21. "Basic Laws," part 2.

22. Office of the Press Secretary, "Executive Order 13526—Classified National Security Information," press release, White House, December 12, 2011, https://obamawhitehouse.archives.gov/.

23. *Too Many Secrets: Overclassification as a Barrier to Critical Information Sharing: Hearing before the Subcommittee on National Security, Emerging Threats and International Relations of the Committee on Government Reform*, 108th Cong. (2004) (Washington, DC: Government Printing Office, 2005), https://www.govinfo.gov/.

24. *Too Many Secrets,* 4.

25. Information Security Oversight Office, *Developing and Using Security Classification Guides* (Washington, DC: NARA, October 2018), https://www.archives.gov/.

26. A. Martínez and Greg Myre, "Mishandling of Classified Documents Happens More Than You Might Think," *Morning Edition*, NPR, radio broadcast, transcript and MP3 file, 3:38, January 19, 2023, https://www.npr.org/.

Many of the vulnerabilities attributed to the classification system can be linked to the sheer volume of information that is generated and the incentive to overclassify that same information through these derivative authorities. The current number of classified documents retained by agencies in the executive branch is unknown, but it is estimated that a document is marked classified three times every second.[27] By the end of the Obama administration, the federal government was spending $18 billion to protect national security information, the majority of which was in the form of classified documents.[28] While the Department of Defense has a formal and informal process to challenge/change classification decisions, some cases can result in a months-long process.[29]

Dissemination and Storage

Due to the siloed nature of classified IT systems, classified products are often printed and stored or disseminated by hand, ultimately creating a myriad of vulnerabilities for programs and agencies. In fact, the risks involved in the proper handling and storage of classified documents have recently gained global attention through a series of high-profile incidents. The current president, a former president, and a former vice president are all involved in investigations relating to the possible mishandling of classified documents.[30]

In addition to mishandling, the creation of new classified products increases the risks of unintentional and intentional unauthorized disclosure. Due to the nature of classified information, it only takes a small volume of data to cause grave harm to operations and undermine national credibility. While unauthorized disclosure figures are not generally published by the government, a declassified Central Intelligence Agency document detailed 292 reported unauthorized public disclosures of classified information between 1959 and 1977 that potentially compromised vital sources and intelligence collection means.[31] In a recent case in April 2023, Airman First Class Jack Teixeria of the Air National Guard was accused of intentionally sharing classified information relating to the supply of lethal aid to Ukraine and the movement of

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[27] Matthew Connelly, "Is the U.S. Government Designating Too Many Documents as 'Classified?,'" interview by Dave Davies, *Fresh Air*, NPR, radio broadcast, summary transcript and MP3 file, 38:15, January 19, 2023, https://www.npr.org/.

[28] Connelly, 3.

[29] GAO, "National Security: DOD and State Have Processes for Formal and Informal Challenges to the Classification of Information," report to the Honorable Christopher S. Murphy, US Senate, GAO 21-294 (Washington, DC: GAO, April 16, 2021), https://www.gao.gov/.

[30] Meg Kinnard, "A Side-by-Side Look at the Trump, Biden Classified Documents," Associated Press, January 14, 2023, https://apnews.com/.

[31] Central Intelligence Agency, s. v. "Unauthorized Disclosure of Classified Information," Freedom of Information Act Electronic Reading Room, March 1977, accessed March 11, 2023, https://www.cia.gov/.

Ukrainian forces. The intentional disclosure of classified data jeopardizes established foreign partnerships and discourages the cooperation of emerging Allies.[32]

In late 2022, the Hudson Institute made a series of classification process reform recommendations. By developing narrow criteria for classification and leveraging artificial intelligence to assist in marking information, the tendency to overclassify as a default will be easier to overcome.[33]

Impediments Arising from Classification

A number of classification concerns including overclassification, excessive infrastructure mandates, and lack of autonomous capabilities for classified systems have direct, negative consequences for the Department of Defense and the Space Force in particular, related to operations, acquisitions, and interoperability with foreign partners.

Operations

In 2004, a House of Representatives subcommittee on national security held a hearing on the issue of overclassification.[34] The subcommittee cited the espionage challenges during the Cold War from a "monolithic" enemy in the Soviet Union as possibly having driven a need to overclassify information to protect it.[35] The committee went on to discuss the findings of the 9/11 Commission Report published that year: "Current security requirements nurture overclassification and excess compartmentation of information among agencies. Each agency's incentive structure opposes sharing, with risks—criminal, civil, and internal administrative sanctions—but few rewards for sharing information."[36]

Excessive compartmentalization prevents national security practitioners from fully understanding their service capabilities, including critical gaps that demand advocacy. From an operational lens, a lack of cross-sharing between agencies ultimately leads to the development of poor assumptions that can undermine the Joint planning process.

For example, former Secretary of Defense James Mattis' frustration with the overclassification of products and communication within the department famously led him to create a coffee mug imprinted with the words "YESFORN."[37] Caveats that further compartmentalize classified information, such as NOFORN, prevent the lateral sharing of vital operational information to Allies and partners, many times due to over-

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[32] Beth Treffeisen and Glenn Thrush, "Airman Pleads Not Guilty to Federal Charges in Leaks Case," *New York Times*, June 21, 2023, https://www.nytimes.com/.

[33] Matt Arnold, "Reforming the Classification System: Challenges, Approaches, and Priorities," *Transforming Classification*, December 8, 2022, https://transforming-classification.blogs.archives.gov/.

[34] *Too Many Secrets*, 4.

[35] *Too Many Secrets*, 2.

[36] *Too Many Secrets*, 3

[37] US Marine Corps, "Marine Corp Design and Joint Warfighting," Commandant Lecture Series, Air Command and Staff College, Maxwell AFB, AL, February 2023.

classification.[38] Rapid information-sharing between international partners ultimately forms the base of the Joint planning process that determines the success or failure of coalition forces.

Acquisitions

Consistent with the sentiment of other senior leaders, the first chief of space operations, General John W. Raymond, considered overclassification a major impediment in space systems acquisitions.[39] Overclassification restricts how the US Space Force integrates with the commercial space industry from the onset of the requirements development process. Limiting the pool of potential companies to engage with and award contracts to also means limiting the diversity of ideas and unique solutions for technically complex challenges in space.

In addition, the facilities and network systems requirements associated with classified acquisitions present a considerable barrier to entry for nontraditional defense contractors. Small businesses and tech start-ups are forced to weigh opportunity costs and decide if time-consuming and substantial up-front infrastructure investments are worth having only for an opportunity to compete for US Space Force contracts.

Further, due to the stand-alone nature of the IT networks, classified procurements rarely have access to any contract automation systems. The lack of automation increases the likelihood of human error and breaks the link in the electronic award system process—such as from contract signature to the payment system—requiring manual inputs at every step of the process.[40] In addition, classified procurements are still beholden to the FAR and the principles of CICA to maximize commercial market participation. Classification-related restrictions on the competition often require time-consuming external approvals, and depending on the level of classification, market research may be limited to a small group of preapproved vendors.[41]

Communications with potential contractors are tightly controlled through security classification guide requirements, security office personnel, and infrastructure capacity. Limited means of communication—such as secured fax only—and layers of security approval add time to the procurement cycle that must be accounted for.

Foreign Military Sales

Equal to the operational considerations, classifications associated with space systems procurements complicate foreign military sales (FMS) between the United States and its

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[38] *Too Many Secrets*, 4.

[39] Fahs, "Gen. Hyten."

[40] *Procure to Pay (P2P) Standard Operating Procedures (SOP) for Distributing Acceptance Receipt and Electronic Receipt and Processing of Requests for Payment ("Handshake 1")* (Washington, DC: DoD, June 29, 2021), https://www.acq.osd.mil/.

[41] DFARSPGI [Defense Federal Acquisition Regulation - Procedures, Guidance, and Information], "PGI 204.402 Safeguarding Classified Information within Industry," Acquisition.gov, August 17, 2023, https://www.acquisition.gov/.

Allies. Under FMS authorities, space capabilities and materials that would traditionally be restricted through Export Administration Regulations or International Traffic in Arms Regulations are permitted to be sold as defense articles for Allied nations.[42]

In 2021, the US Space Force Space Systems Command created an office of international affairs that reported $3 billion in current FMS acquisitions across 58 international partnerships in addition to projecting an additional $5 billion over the next three fiscal years.[43] The overclassification of US Space Force space systems restricts communications between the acquisitions teams and international partners at the critical first step of establishing the business case. Complicating the FMS process prevents Allies and partners from filling critical gaps in space-based capabilities and diminishes the Department of Defense's ability to lead in the space domain.

Space Force Classified Contracting

Space Systems Procurement

To assess the current classified contracting process and environment at the execution level, survey questions were sent to contracting officers procuring US Space Force space systems at varied levels of classification. The first half of the questions focused on the competitive landscape and how potential companies are identified through the market research phase. The majority of the responses centered on utilizing existing lists of cleared contracted personnel that were maintained by their respective security office, organizing industry days (limited to cleared personnel), and attending conferences to identify potential contractors.[44]

Citing the restricted nature of their contractor base as a potential reason, nearly 90 percent of their respective portfolios have been contracted to established large businesses. The use of other transaction authorities among the respondents was minimal, and while all of the contracting officers were actively seeking out new entrants to defense contracting, the vast majority of their competitive pools are static and only change as a result of mergers or corporate restructuring.[45]

The second half of the survey focused on contracting tools and competitive practices within organizations. All respondents noted the lack of automation and disparate/antiquated communication networks added time to the procurement process.[46] Contracts are written on Microsoft Word, financial data is tracked on Microsoft Excel, and in one case it took five weeks for a contractor to receive a request for proposal over

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[42] "FMS [Foreign Military Sales] FAQs," US Department of Commerce, Bureau of Industry and Security, updated May 12, 2021, https://www.bis.doc.gov/.

[43] Space Systems Command (SSC), "International Affairs (SSC/IA)," accessed March 5, 2023, https://www.ssc.spaceforce.mil/.

[44] SSC, "Competition."

[45] SSC, 2.

[46] SSC, 2.

secured fax due to the limitations of the technology and coordination required on the receiving end.

The responses on competitive practices were consistent among the offices: even under classified restrictions, the majority of their contract awards were made through competition. While the frequency of competition was consistent, the final contract price to the government bore the high costs of added security infrastructure and retention of cleared personnel who are becoming difficult to incentivize due to outside telework opportunities, since there is no telework from a SCIF.[47]

Barriers to Entry

To do business with the government on any contract that requires handling or storing classified material, potential contractors are subject to the DoD contract security classification specification, or Form DD-254. The DD-254 is an attachment to a request for proposal—and contract, once awarded—and serves as a certification that all of the applicable criteria of the National Industrial Security Program Operating Manual (NISPOM) have been satisfied.[48]

New entrants to the defense sector require a minimum of an interim DD-254 to compete for or be made aware of classified work, setting up a "wait and see scenario."[49] A new entrant must work to satisfy select requirements in the NISPOM to gain an interim status before having access to the request-for-proposal process and fully understanding the government's needs.[50] In the event a new entrant with an interim DD-254 status earns business with the government, the DD-254 must be finalized, with all NISPOM requirements met, before the final award of the contract.[51] Meeting the requirements of the NISPOM is time- and capital-intensive, especially for small businesses.

The cost to conduct a Tier 5 security clearance investigation (Top Secret/sensitive compartmented information) is just over $5,000, and the average processing time takes approximately four months, assuming there are no issues or delays.[52] Additional SAP clearances require more processing time, putting small businesses in a position to carry tens of thousands of dollars in security clearance-related costs that they would otherwise not have to consider in commercial industry.

The time and capital investments involved in classified infrastructure also impose significant opportunity costs on small businesses. A small container-sized SCIF workspace (320 square feet) can cost as much as $245,000, and that does not include the cost of secured networking equipment and approved storage containers. Once the

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47. SSC, 3.

48. DFARSPGI, "PGI 204.402."

49. *Part 117 - National Industrial Security Program Operating Manual (NISPOM)*, 85 Fed. Reg. 83312 (December 21, 2020), https://www.ecfr.gov/.

50. DFARSPGI, "PGI 204.402."

51. DFARSPGI, 1.

52. Lindy Kyzer, "How Long Does It Take to Get a Security Clearance? Q4 2022," ClearanceJobs (website), November 2, 2022, https://news.clearancejobs.com/.

SCIF structure and networks are established, the required facility clearance process can take up to five months, assuming no delays.[53] In the age of telework and dispersed operations that decrease overhead and operating costs, substantial investments in brick-and-mortar SCIFs could run hundreds of thousands of dollars that would not be a factor in the commercial industry.

Competition and Its Effects on Innovation

Aside from ensuring adequate price competition to find the best business deal for the government, CICA was put in place to encourage better contractor performance. Successful companies in some highly competitive fields will provide superior service while keeping their prices within the market average. In the case of DoD contracted work for research and development requirements, the primary focus is on finding the best technical solution, and price considerations are typically less important. Finding the best technical solutions for complex challenges in the space domain requires a diversity of thought that encompasses a wide field of subject matter experts who may work outside of the established defense industry.

Once space system research and development work is complete through prototyping, the production and sustainment requirements become highly susceptible to vendor lock.[54] Throughout DoD procurement history, intellectual property or data rights, proprietary technology, and closed architecture design have stifled the competitive process and potential innovations that may follow. For classified requirements that are unable to leverage a program such as the Small Business Innovation Research program—which acts as a seed fund and was established in 1982 to "encourage domestic small businesses to engage in Federal Research/Research and Development with the potential for commercialization"—the issue of vendor lock is far more acute.[55]

If it is assumed that the most highly specialized US Space Force space capabilities are protected through the highest levels of classification, only a finite number of companies will be able to compete to improve upon existing technology or find new approaches. This lack of competition restricts the diversity of solutions that come from sources such as nontraditional defense contractors and provides little incentive for established prime contractors to be innovative and reach beyond sole-source guarantees.

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[53] Andrea Johns, Jennifer Wagner, and Elizabeth Mudd, "Roadmap to Getting a Facility Clearance" (online presentation, DoD, Office of Small Business Programs and Defense Acquisition University, June 24, 2020), https://business.defense.gov/.

[54] Virginia L. Wydler, *Gaining Leverage over Vendor Lock to Improve Acquisition Performance and Cost Efficiencies* (McLean, VA: MITRE Corporation, April 2014), https://www.mitre.org/.

[55] SBIR [Small Business Innovation Research] and STTR [Small Business Technology Transfer], "About," SBIR.gov, accessed March 9, 2023, https://www.sbir.gov/.

Proposed Solutions

Original and Derived Classification Authorities

Since classification and the process of protecting national secrets is a wholly government-owned process, those with original classification authority for their respective agencies hold immense power over information and how it is handled. The eight categories for classification detailed in Executive Order 13526 will not always lead to black-and-white decision-making, forcing an OCA to carefully weigh classification options.[56] To achieve a comprehensive evaluation, the operational risks and acquisition-related costs must be equally considered.

For acquisition programs or capabilities that must be classified, the OCA should carefully consider the appropriate level of classification and not default to the maximum level of restriction. Through current policy change, security classification guides and program security guides could be written in a way that provides latitude to those with derivative classification authority to account for additional controls after capabilities are better understood once acquisition milestones, such as initial operational capability, are reached.

While the OCA establishes the baseline for classification, as noted previously, those who possess derivative authorities, or all cleared personnel, are responsible for the generation of millions of documents, many of which are overclassified or mislabeled.[57] Expanded electronic file storage and transmission through secured networks have largely removed the burden of storing/accounting for physical material in a secured container. This has incentivized overclassification when a derivative classifier is in doubt.

Through the use of commercial machine-learning applications, such as Grammarly, that could be adapted for use on stand-alone systems, security classification guides and program security guides could be programmed into the app and could match the content in electronic products against the actual classification criteria. Cleared personnel could be prompted on potential overclassification designations in real time. Within combined and coalition offices, these applications could be adjusted to account for NATO and/or foreign-partner criteria, significantly reducing human error and friction points in data-sharing.

Small Businesses

For all of the new jobs created between 1995 and 2020, small businesses accounted for 12.7 million, or 62 percent, of that total.[58] In 2019, an estimated 44 percent of US economic activity came from the small business sector, and on average it produced 14

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[56] Exec. Ord. No. 13526.

[57] *Too Many Secrets*, 3.

[58] Martin Rowinski, "How Small Businesses Drive the American Economy," *Forbes*, March 25, 2022, https://www.forbes.com/.

times more patented technology than large businesses.[59] For decades, the Department of Defense has leveraged the innovative might of the country through the Small Business Innovation Research program. With the codification of the Other Transaction authorities process in 2015, the US Space Force is positioned to access a tech sector that was assumed to be closed to government contracts in the past.

To maintain a viable defense industry that is cleared to perform classified work, competent small businesses and tech start-ups need to be identified through a classified consortium or a Small Business Innovation Research-equivalent program that can provide seed funds. Secured SharePoint sites that are networked through an intranet between terminals—like SAM.gov, the System for Award Management website—could be used where the government posts unclassified solicitations for contracted work, allowing acquisition professionals to quickly assess company capabilities through the market research process. For technology that cannot be later commercialized due to classification, companies still have the option to pursue follow-on production opportunities with the government through the expanded use of Other Transaction authorities.

The ability to unleash tech startups and emerging small businesses will hinge on financially viable access to sensitive compartmented information facility spaces and secured networks. Keeping highly capable employees on payroll will require small businesses to rapidly compete for and earn contracted work with the government. Through the use and evaluation of small business subcontracting plans and small business participation goals, acquisition teams can encourage large businesses with existing SCIF infrastructure to subcontract with emerging small businesses and start-ups.[60] Small business subcontracting plans can be prioritized and heavily weighted through the evaluation and source-selection or contract award process, giving prime contractors an incentive to maximize their participation.

Lowering Barriers to Entry

Small businesses and tech start-ups that are new to defense contracting are accustomed to commercial business practices that rely heavily on profit-driven efficiencies and lean operations. The regulatory burden of FAR-based contracting imposes considerable time and capital costs through mandatory compliance clauses and aggressive oversight in the case of cost-type contracts. And the additional layers of bureaucracy imposed through clearance investigations, DD-254s, and the facility clearance process may be the final hurdles that discourage new entrants and turn them back toward an unclassified, unencumbered commercial sector.

The processes specific to classified work must be streamlined in a way that prioritizes critical capabilities and current skill gaps. Like the DD-254 digital reforms made in 2019, paper copy tracking for facility clearances and clearance investigations must

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[59] "Innovation and Research," US Senate Committee on Small Business & Entrepreneurship (website), accessed March 9, 2023, https://www.sbc.senate.gov/.

[60] DoD, *DoD Source Selection Procedures* (Washington, DC: DoD, August 20, 2022), https://www.dau.edu/.

be eliminated.[61] In addition, different clearance levels and program associations should be prioritized for processing in accordance with national defense skill shortages and urgent operational needs. If everything is a priority, nothing is a priority, and five-months processing times cannot accelerate change.[62]

Not to be neglected, the current large business prime contractors that compose the bulk of the classified sector capability must be incentivized to maintain aging SCIF infrastructure and retain competent personnel who can keep security clearances. In a postpandemic world, the flexibility and convenience of telework has become a strongly preferred employment arrangement by potential employees across many professions. The classified industry must stay competitive in an environment where nearly all of the work is accomplished in person.

After seeing some of the existing contracted companies walk away from classified opportunities due to the postpandemic job markets, one of the interviewed space system contracting officers proposed introducing National Defense Authorization Act language that would incentivize existing prime contractors to maintain their SCIFs and cleared status.[63] Through possible grant programs and regulatory relief, a large business with decades of experience and vital defense skill sets would be given means to attract and retain talented personnel who would otherwise be drawn to the nondefense commercial sector.

Expanded Tools

The US Space Force acquisitions career field is built on the creation and efficient control of documentation. For those in the contracting profession, digital interfaces and cloud-hosted networks have eliminated the need to ever create or retain paper contracts in just about every setting.

Since 2018, the contracting career field has adopted a significant amount of automation through web-based platforms such as Contracting Information Technology that replaces unsupported software that had been in use since the mid-1990s.[64] The procurement process requires cross talk through multiple systems that write contracts, request proposals, award contracts, pay vendors, and rate contractor performance, to name a few. Unfortunately, little to no automation or system cross talk exists for classified contracting that is executed on stand-alone systems.

Initiatives such as the DoD Procure to Pay future contracting plan should prioritize the development of Contracting Information Technology-like applications that

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[61] *Federal Acquisition Regulation: Requirements for DD Form 254, Contract Security Classification Specification*, 84 Fed. Reg. 33201 (July 12, 2019), https://www.federalregister.gov/.

[62] Charles Q. Brown Jr., *Accelerate Change or Lose* (Washington, DC: Headquarters US Air Force, August 2020), https://www.af.mil/.

[63] SSC, "Competition," 2.

[64] George Sarmiento and Jonathan Owen, "Contracting-Information Technology (CON-IT) at a Glance," Air Force BES [Business and Enterprise Systems], November 17, 2022, https://www.airforcebes.af.mil/.

can be used on secured networks.[65] Increased automation in the contract writing and award process will decrease human error and accelerate procurements by several factors.

Aside from automation in the classified setting, contracting officers must be given new tools to expand their vendor base and boost competition. The current DD-254 process is cumbersome and requires significant up-front investments that must be carried for months before the prospect of earning government work is ever realized. Formal agreements with the government, such as a cooperative research and development agreement (CRADA), allow for work between federal and nonfederal entities on a noncontract basis.[66]

For classified requirements, CRADAs could be leveraged to start the personnel clearance process and could result in collaborations with companies that enable a full understanding of the government's need. Contracting officers should be given CRADA or equivalent program approval authorities to seek out and establish formal ties with potential contractors during the market research phase. Expanding the vendor base will drive innovation and deliver the complex solutions required by the space domain.[67]

Conclusion

In order to protect US national interests, the classification system, derived from presidential authority, will continue to be leveraged to protect national secrets and associated space program acquisitions. Due in large part to the recent media reporting on overclassification, the detrimental operational effects on deterrence, the Joint planning process, and work with Allies and partners are well known. Since the acquisition community works in a supporting role to the warfighter, the level of effort and infrastructure required for classified efforts may not be as visible to the public.

Overclassification and the misuse of derivative authority lead to the sacrifice of procurement speed, cost, innovation, and Allied partnerships. To make a fully informed decision to classify a program or capability, the original classification authority must weigh the operational and acquisition consequence of that decision. Above all else, the classified environment must be transformed and adapted to keep pace within a competitive space domain.

The Department of Defense currently has the means and capability to streamline the classified procurement process and fully harness the diversity of thought in companies across the country. Through the application of commercial machine learning onto classified stand-alone systems, automation can reduce human error and significantly increase the speed of procurements. Through the reform of current security regulations and policy, many of the associated prohibitive costs imposed on companies

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[65] *Procure to Pay*.

[66] US Department of the Interior (DoI), "CRADAs - Cooperative Research & Development Agreements," DoI, March 25, 2021, https://www.doi.gov/.

[67] DoI.

can be reduced or eliminated. By lowering the barriers to entry for classified work with the government, competition will increase dramatically, ultimately pushing the boundaries of innovation in a technically complex domain. Due diligence and the avoidance of overclassification will strengthen ties with Allies and partners and ensure critical space-based capabilities are delivered on time and on budget.

In the era of strategic competition, Department of the Air Force personnel must be empowered to take risks, and that all starts with the way information is held. Airmen and Guardian acquisition professionals should be incentivized to classify only if absolutely necessary. They should also be empowered to efficiently and effectively prosecute classified space programs on all information that requires classification. ***Æ***

DECISION SUPPORT SYSTEMS FOR CRITICAL SPACE INFRASTRUCTURE ASSETS

Devon L. Brown
Danielle Ciesielski
Duli Chand

Persistent regional and global power dynamics will ensure that adversaries will continue to push boundaries in the geopolitical, economic, technological, intelligence, and military arenas. Improved tactics, techniques, and procedures are needed to address, mitigate, and counter behaviors critical to the United States, as nations and nonstate actors test new norms across all warfighting domains, space in particular. In order to analyze and process multidomain signatures in support of operational decision-making, the United States can harness artificial intelligence and machine learning decision support system statistical models to augment collection capabilities, data repositories, and threat analysis.

On January 28, 2023, a People's Republic of China (PRC) surveillance balloon entered US airspace near the Aleutian Islands and traveled over the continental United States and Canada. On February 4, it was shot down off the coast of South Carolina by the US Air Force.[1] Two days prior to the incident, the US government reported the object was making its way toward US airspace, but given the threat analysis, the report was not flagged as urgent. The incursion provides further evidence that as strategic competition increases, adversaries will continue to push boundaries in a number of arenas, including technology, geopolitics, economics, intelligence, and military. The balloon incident also emphasizes the importance of adequately characterizing the threat level of reporting in the diplomatic, homeland defense, military, and intelligence sectors, specifically for national and international security professionals in the air and space domains.[2]

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[1] Jim Garamone, "F-22 Safely Shoots Down Chinese Spy Balloon off South Carolina Coast," Department of Defense (DoD) (website), February 4, 2023, https://www.defense.gov/.

[2] Katie Bo Lillis et al., "Initial Classified Balloon Report Wasn't Flagged as Urgent, Drawing Criticism," CNN, February 8, 2023, https://www.cnn.com/.

Governments and private organizations around the world are gradually embedding artificial intelligence (AI) into their systems to solve emergent problems with untested technologies. Adversaries are advancing technologically and challenging the United States, its Allies, and partners with aggressive space asset maneuvering, while also funding innovative ideas that disrupt markets to gain strategic advantage over competitors.[3]

As these new capabilities come online, it is critical now more than ever to employ more than just a dashboard with analytics. The Intelligence Community must harness the vast amounts of data collected to supply probabilistic correlation, outcomes, and insights where none existed in the past. Using this understanding, analysts can more effectively identify anomalies and present probabilistic outcomes in support of contingency planning.

Background

Since the passage of the Intelligence Reform and Terrorism Prevention Act of 2004, the decision space has evolved to include numerous emerging threats, particularly adversary space operations.[4] Improved tactics, techniques, and procedures are needed to characterize such behaviors as nations test new norms across warfighting domains. The government's timely and effective response to these events is critical.

Measurement and signature intelligence (MASINT) serves as a technical concentration for intelligence officers and technical staff who focus on collecting scientific and technical intelligence on any given target. In the space domain, radio, electro-optical, geophysical, and other types of signatures collected from targets are essential when combined with operational data. Due to the fact that human interaction is limited in space, MASINT plays a critical role when analysts characterize space assets. By harnessing a decision support system (DSS) with robust threat analysis data, the US government will be able to accurately characterize these threats and inform senior leadership with the most accurate threat-level analysis.

The lack of transparency and automation in disjointed systems hinders the time from collection and analysis to a final decision. A decision support system—an information system that analyzes and synthesizes vast amounts of information to assist in the decision-making process—that encompasses accurate multidomain signatures is vital. A DSS will allow analysts to identify anomalies and advise decisionmakers when considering kinetic, nonkinetic, electromagnetic, or cyber defenses.

This article recommends a change to space-threat analysis strategy by applying AI and machine learning (ML) DSS statistical models that harness US collection capabilities and the interagency information-sharing environment. These models can streamline decision-making processes by determining probabilistic outcomes from disparate

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[3] Nicholas Deschenes, "Enabling Leaders to Dominate the Space Domain," *Military Review* (May-June 2019), https://www.armyupress.army.mil/.

[4] Intelligence Reform and Terrorist Prevention Act of 2004, P. L. No. 108-458 (2004), https://www.govinfo.gov/.

datasets. A robust decision support system can assist with distributing resources effectively and analyzing trends between disparate datasets and systems where anticipatory probability analysis is not available. Now is the opportunity for the Intelligence Community to employ advanced analytical techniques to adapt to the ever-changing security environment.

After the 9/11 attacks on the United States, the Intelligence Reform and Terrorism Prevention Act of 2004 was enacted in order to enhance national security information-sharing between departments and agencies. Given the focus on strategic competition between nations and the effort to "enhance the resilience of US space systems" necessary for "critical national and homeland security functions" in the 2022 *National Security Strategy*, the intelligence sector should also shift to offer analytical support in these areas.[5]

Data and the Space Domain

The creation of the US Space Force and threat testimony from senior leaders has eased the learning curve for decisionmakers in the space domain. As additional parties such as private organization and nonstate actors participate in the space domain, combatant command commanders will need to provide presidents, defense secretaries, the Joint chiefs, and congressional representatives timely, accurate reporting on threats and vulnerabilities. Equipping commanders and operators with a decision support system that captures the relationship between threat analysis and operational atmospherics will enable commanders to give readily available accurate threat analysis to inform national-level strategic decision-making.

Emerging AI/ML analytical models connected to multidomain systems can build knowledge and understanding throughout the decision chain of command. Yet disruptive technologies, such as generative AI, acting to amplify misinformation and disinformation, affect how decisionmakers in the US government ingest indicators from multiple domains. This makes it difficult for senior leadership in the executive and legislative branches to build consensus around threats and formulate an inclusive national security strategy. A dependable and robust DSS that includes statistically probabilistic models will encourage national leaders to invest in robust threat analysis using internal mechanisms.[6]

Resources are scarce in the space domain. It is difficult for stakeholders to characterize how the geopolitical environment affects the relationship between operational planning and critical infrastructure in space. Nations are challenging international norms by pushing boundaries, including the tolerance for kinetic war and the use of disruptive technologies. As the United States, its Allies, and partners strategically position their countries for the next 15 to 20 years, based on the Artemis Accords and

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[5] Joseph R. Biden Jr., *National Security Strategy* (Washington, DC: White House, October 2022), 8–9, 45.

[6] Tom Di Fonzo, "What You Need to Know about Generative AI's Emerging Role in Political Campaigns," Tech Policy Press, October 12, 2023, https://techpolicy.press/.

planned space missions, these nations have an opportunity to rethink policy and strategy in an already congested space domain.

Commercial, government, and Ally activities in the space domain complicate the decision space when dual-use assets are involved. With orbital assets dependent on critical ground infrastructure, collaboration with the private sector becomes paramount.[7] Artificial intelligence/machine-learning DSSs provide strategic advantage by distributing resources effectively. Decision support systems take large amounts of unstructured data and assist with mid-level analysis when building relationships between datasets manually by analysts is unfeasible. By building out known variables within the DSS and adding new threats as they arise, the statistical models will be able to adjust as the threat landscape changes.

Values

During the developmental phase of any national-level system, the US Constitution and international law norms must be integrated to eliminate biases and outright violations of the Law of Armed Conflict in the system's recommendations to decisionmakers. Ethics and bias concerns in AI/ML models stem from priorities and data abnormalities when training such models. When discussing values and ethics, it is important to consider the drivers for innovation and technological advances.

Today, commercial and economic indicators propel technology development and innovation.[8] Economic gain, patents, and selling access to technology drive technology development in the private sector while government-funded labs are more focused on bleeding-edge research, standards, science, and technology. The space race to the moon from the 1950s to the 1960s is a prime example. National security and strategic competition were the motivators for obtaining the high ground. In response, the United States mobilized resources and personnel in its space race against the Soviet Union.

Fast forward to the 1980s and 1990s, when funding for technology and innovation was channeled through labs or advanced programs focused on long-term research and development, leading to the current state of affairs where private organizations drive innovation and are deeply ingrained in government operations and systems. For example, SpaceX initially supported communications and operations by supplying broadband services to Ukraine's military during Russia's invasion. Yet, at a February 2023 conference, SpaceX's president and chief operating officer noted, "Ukrainians leveraged the systems in ways that were unintentional and not part of any agreement" by using SpaceX's Starlink satellite system to weaponize drones.[9] This raises a valid question on how dual-use systems in the private sector are employed to support

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[7] Biden, *National Security Strategy*, 45.

[8] Ash Carter, "The Moral Dimension of AI-Assisted Decision-making," *Daedalus* 151, no. 2 (Spring 2022), https://www.jstor.org/.

[9] Joey Roulette, "SpaceX Curbed Ukraine's Use of Starlink Internet for Drones," Reuters, February 9, 2023, https://www.reuters.com/.

military efforts and on the ethical considerations for using commercial services in the support of war campaigns.

In another modern example, Open AI's ChatGPT motivated Microsoft and Google to invest in large language models. Microsoft's preliminary test with the Bing search engine raised concerns among ethicists who questioned if chat-enabled search was premature for the market.[10] The examples of SpaceX and Microsoft show how private-sector competition for technological advantage may hastily move products to market without considering all the applications for the technology. For the US government, such examples offer an opportunity to consider how AI/ML models affect national security, information operations, and geopolitical strategy. Government policy, standards, and research on these technologies will not only aid the private sector in developing ethical systems, but also encourage innovation.

Historical evidence shows the US government is heavily dependent on commercial space technologies. This can be a problem in terms of national security. For example, in the 1990s, US companies Loral Space & Communications Ltd. and Hughes Electronics violated export controls laws, and as a result, inadvertently transferred technological insights to China.[11] This subsequently led to satellite systems' export licensing moving from the Department of Commerce to the Department of State under International Traffic in Arms Regulations.[12] While protecting US dual-use space technologies from adversaries is paramount, it will be imperative to balance the benefit of US space export policies and controls as emerging technologies and techniques start to integrate into critical space infrastructure.

As this article investigates these strategic and ethical considerations, it will highlight applications for DSSs in the space domain and current research into AI/ML models, and it will examine the evolving space/counterspace efforts as a stage for strategic competition.

Decision Support Systems

Strategic Approach

Analysts rely on community knowledge, expertise, and collection taskers to prepare briefing materials. For the Biden administration, under the structure of the National Security Council, the most senior civilian and military decisionmakers regularly meet to receive numerous briefings from the Department of Defense and

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[10] Cindy Gordon, "Why Is Microsoft's New Bing ChatBot Raising Ethical Eyebrows?," *Forbes*, February 21, 2023, https://www.forbes.com/.

[11] *Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China*, Rpt. 105-851, 105th Cong. (1999), xiv–xxi, https://www.govinfo.gov/.

[12] *China: Possible Missile Technology Transfers under U.S. Satellite Export Policy – Actions and Chronology*, 98-485 (Washington, DC: Congressional Research Service, updated October 6, 2003), https://www.everycrsreport.com/; and Chad J. R. Ohlandt, "Competition and Collaboration in Space between the U.S., China, and Australia: Woomera to WGS and the Impact of Changing U.S. National Space Security Policy," *Asian Survey* 54, no. 2 (2014): 406–7, https://doi.org/.

other departments and agencies. Armed with this national-level unclassified and classified information, the National Security Council formulates national security policy.[13] Equipping these national security leaders with correlated information from diplomatic, science, economic, technical, military, and health sectors will enable officials to better understand the decision space and accurately characterize how each decision may affect a given sector.

Each agency has its own taxonomy for classified material. These systems identify how the agency stores, classifies, and structures classified data. Decision support systems can harness those taxonomies to build relationships between legacy systems and cut redundant processes. Intelligence Community Directive 203 provides analytic standards to ensure reporting is transparent, timely, and accurate, as well as ethically aligned in terms of "objectivity, bias, politicization, and other issues" with the Intelligence Community.[14] Incorporating AI/ML-enabled DSSs into analytical standards will ensure analysts can effectively use all-source intelligence to build correlations from common indicators throughout government and open-source channels.

The Augmenting Intelligence using Machines (AIM) strategy from the Office of the Director of National Intelligence emphasizes that "closing the gap between decisions and data collection is a top priority for the intelligence community."[15] Collection strategies over the past 20 years accumulated massive amounts of data in disparate systems. These systems have grown organically to share information on common platforms; however, logging into multiple systems and synthesizing the information manually slows down the analysis process and is inconsistent from analyst to analyst.

The Department of Defense classifies AI/ML efforts for decision support as systems of systems to wargame, calculate mission success, measure risk, and provide command and control for warfighters and commanders.[16] Systems of systems brings together disparate systems to offer insights that may not be available during the speed of battle. These insights allow commanders to make more informed decisions. Further, the Department of Defense implemented five ethical principles through its responsible AI doctrine: responsible, equitable, traceable, reliable, and governable. It also created the Joint Artificial Intelligence Center to implement this guidance throughout the Department.[17]

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[13] Memorandum on Renewing the National Security Council System White House (website), February 4, 2021, https://www.whitehouse.gov/.

[14] James Clapper, "Analytic Standards," Intelligence Community Directive 203, January 2, 2015, 2, https://www.dni.gov/.

[15] Office of the Director of National Intelligence (ODNI), *The AIM Initiative: A Strategy for Augmenting Intelligence Using Machines* (Washington, DC: ODNI, January 16, 2019), 3, https://www.dni.gov/.

[16] K. C. Miller et al., "Merging Future Knowledgebase System of Systems with Artificial Intelligence/Machine Learning Engines to Maximize Reliability and Availability for Decision Support," *Military Operations Research* 26, no. 4 (2021), https://www.jstor.org/.

[17] Deputy Secretary of Defense, Memorandum for Senior Pentagon Leadership Commanders of the Combatant Commands Defense Agency and DoD Field Activity Directors, Subject: Implementing Responsible Artificial Intelligence in the Department of Defense, May 26, 2021, https://media.defense.gov/.

In comparison, the AIM initiative in the Intelligence Community focuses on narrow AI in the short term to leverage private-to-government relationships and investments. Medium-term investments will focus on AI assurance and basic research to fuse data and information from disparate domains or intelligence sectors to create a better understanding of collected data.[18] Ultimately, however, the AIM initiative and DoD systems-of-systems efforts in AI/ML are both needed to address issues particular to their sector. One overarching policy or initiative is not enough to account for all government agencies.

Research and resources are key to advancing AI/ML initiatives, but partnerships and foreign policy are critical since these technologies have global reach. Due to the increased number of countries implementing AI into autonomous systems, the Bureau of Arms Control, Verification, and Compliance at the Department of State issued the *Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy* to push countries to implement risk/benefit analysis and responsible human chain of command and control when dealing with weapon systems.[19]

As the Department of Defense and the Intelligence Community invest in AI/ML infrastructure, talent, and capabilities, the Department of State would also benefit by facilitating conversations with partners and Allies, especially when considering AI/ML in the space domain.

US Space Command

In March 2022, Commander of US Space Command General James Dickinson identified Russia and the People's Republic of China as major security challenges and persistent threats, outlining examples of kinetic, antisatellite (ASAT) weapons tests, and adversary AI/ML systems designed to achieve space superiority.[20] Threats include China's Shijian-17 and Shijian-21 satellites, multiple ground-based laser systems, and the Russian direct ascent-ASAT missile demonstration that created 1,500 pieces of space debris.[21]

During the same Congressional hearing, Dickinson noted US Space Command initiatives maximizing "artificial intelligence, modeling, and simulation to inform space domain awareness." Dickinson informed Congress that in order for the command to be fully operational in this effort, it required "an integrated platform with fully trained modeling, simulation, and analysis personnel, with in-place hardware

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[18] ODNI, *AIM Initiative*, 5.

[19] Bureau of Arms Control, Verification and Compliance, "Political Declaration on Responsible Military Use of Artificial Intelligence and Autonomy," Department of State (website), February 16, 2023, https://www.state.gov/.

[20] *Hearing on National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2023 and Oversight of Previously Authorized Programs, Before the Committee on Armed Services House of Representatives*, 117th Cong., 2nd session (2022) (statement of General James H. Dickinson, commander, US Space Command), 3, https://www.armed-services.senate.gov/.

[21] *NDAA for FY 2023*, 7.

and software tools, with resources required to provide high performance computing across all classification levels" in support of "unbiased and timely assessments."[22]

Dickinson's priorities are driving the command to research AI/ML models in support of defending critical space infrastructure by analyzing capabilities, threats, vulnerabilities, and criticality of orbital assets.

Space Critical Infrastructure Decision Support Systems

US Space Command led efforts in developing an interagency coalition to quantify and assess malicious behavior in the space domain with the goal of defending orbital assets from aggressive/malicious actors in space.[23] The command's educational outreach to professional military education programs focused on key space defense research topics to understand competition, support relationships, and digital superiority, and to integrate commercial and interagency organizations.[24]

The Massachusetts Institute of Technology–Lincoln Laboratories is one of the labs exploring how to characterize capabilities, threats, vulnerabilities, and criticality of orbital assets in the space domain using AI/ML. Their preliminary research explored how AI/ML-enabled DSSs use Bayesian network models to decide criticality for orbital assets.[25] The National Intelligence University undertook research efforts in the fall of 2022 to explore comparative models on criticality and risk management strategies for orbital assets.

Quantifying Space Threats and Vulnerabilities in Contingency Planning

Calculating defensive strategies for orbital assists requires knowledge of defended asset lists (DALs) and critical asset lists (CALs), which are essential during risk and contingency planning at the combatant-command level. Both dynamic lists are essential in determining priorities for all stakeholders in the space domain.[26] Decision support systems in the space domain focus on the highest prioritized assets and forecasting threats and vulnerabilities for those assets in order to develop defense strategies.

It is impossible to defend all assets from every threat in the space domain. The priority critical asset list (PCAL), risk management, and contingency planning are

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[22] *NDAA for FY 2023*, 14–15.

[23] Headquarters, US Space Force (USSF), *Spacepower: Doctrine for Space Forces*, Space Capstone Publication (Washington, DC: USSF, June 2020), https://www.spaceforce.mil/.

[24] Brook J. Leonard, Memorandum for Professional Military Education Programs: Space Defense and War Studies Outreach for Professional Military Education Programs – Academic Year 2023, 1.

[25] Michael B. Hurley, Dan Castellarin, and Jenna Hallapy, "U.S. Space Command Critical Infrastructure Decision Support System (UCIDS): Bayesian Network Overview" (unpublished white paper, Massachusetts Institute of Technology–Lincoln Laboratories, 2022).

[26] Scott Douglas Applegate and Christopher L. Carpenter, "Searching for Digital Hilltops: A Doctrinal Approach to Identifying Key Terrain in Cyberspace," *Joint Force Quarterly* 84, no. 1 (2017): 8, https://ndupress.ndu.edu/.

necessary for the DSS: these elements define government assets and relate them to threats and vulnerabilities. A PCAL drives the development of the DAL and is scored annually during an interagency conference including partners such as the Space Force, the Army, the National Aeronautics and Space Administration, and other departments and agencies. There are six steps in creating the PCAL:[27]

1. Assets/locations given priorities and criticality based on location
    i. Examples: Command-and-control assets, global sensor management, missile warning, Military Satellite Communications Directorate, and intelligence, surveillance, and reconnaissance
    ii. Result: PCAL based on criticality
2. Priorities and criticality analyzed for specific threat environment
    i. Examples: Ground attack, cyberattack, ASAT weapons, and space object surveillance and identification
    ii. Result: PCAL based on criticality, vulnerability, and threat
3. Vulnerability analysis
    i. Example: Susceptibility to attack, resiliency to recover, and redundancy
    ii. Result: PCAL based on criticality, vulnerability, and threat
4. Joint mission thread analysis
    i. Example: Warfighter space dependency model and space interactive blueprints
    ii. Result: Initial PCAL
5. Combatant commander supplies guidance
    i. Example: Human analysis
    ii. Result: Commander's guidance
6. Combine initial PCAL with commander guidance
    i. Result: Joint/combined PCAL

Interagency partners assess criticality, threat, and vulnerabilities by assigning analysis responsibilities to an agency or department's area of responsibility. Critical priorities are space warfare, space service support, space support operations, space domain awareness, and Office of the Director of National Intelligence objectives. Each priority encompasses specific capabilities in an area of responsibility scored on a scale of one to five, with five as the highest threat. Threats like cyberattacks or ASAT weapons are scored as well, using the same scale and categorized by actors that have that capability. Lastly, vulnerabilities are categorized by type and scored using the same scale under orbital or terrestrial domains.[28] These PCAL scores along with the US Space Command commander's guidance allow for the annual interagency development of a Joint PCAL that identifies the most critical assets to protect.

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27. US Space Command (USSPACECOM), "Prioritized Critical Asset List (PCAL)" overview brief (Colorado Springs, CO: USSPACECOM, undated)

28. USSPACECOM, "PCAL" overview brief.

Automating this process with an AI/ML decision support system will not only streamline the process but also uncover dependencies and deficiencies in the analysis process. To narrow the research, this article will analyze how AI/ML can use statistical models to streamline the assessment of space debris, ASAT, and cyberattack threats to orbital assets.

Bayesian Networks for Criticality/Risk Assessments

The use case for Bayesian networks to determine criticality and risk assessments in the PCAL process lies in probability theory, using mathematical formulas to determine conditional probability, or the predicted likelihood of the next output based on a past event's experiences.[29] Bayesian networks incorporate common knowledge to train models that predict the most likely next occurrence of an event.

The use of Bayes' rule for conditional probability underpins this method and states

$$P(Y_i|X)=P(X|Y_i)P(Y_i)/(\Sigma^n\ (P(X|Y_i)P(Y_i)))$$

where X and Y are random variables, Yi denotes a specific variable (among n), and P is a probability distribution function that maps values between zero and one. Initial research from the Massachusetts Institute of Technology–Lincoln Laboratories identifies the chain below in determining nodes in the decision support system:

Actor > Threat > Vulnerability > Domain > Asset Class > Asset > System > Mission

In response to the issue of exponential growth in conditional probability tables, the lab plans to use noisy-Boolean constructs to reduce the complexity of the system, thereby speeding up calculations as the number of inputs increase within the network.[30] Using this methodology, the authors explored AI/ML DSS techniques to understand how these models could determine criticality in three areas: space debris, ASAT, and electronic warfare/cyberattacks.

Space Debris

On average, 21 potential space-collision warnings are issued by the military each day. Researchers are looking into innovative ways to minimize space debris. Initiatives range from developing nets to pushing debris into medium Earth orbit for satellites to hit gravitational resonance over time and burn up in the atmosphere.[31] There are around 55,338 trackable objects consisting of 62 percent debris, 26 percent payloads, 12 percent rocket bodies, and <1 percent unknown. The dataset used to feed the DSS includes the apogee, perigee, inclination, and period for each object and offers to retrieve the following additional information for each:[32]

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[29] Hurley, Castellarin, and Hallapy, "Bayesian Network Overview."

[30] Hurley, Castellarin, and Hallapy.

[31] Alexandra Witze, "The Quest to Conquer Earth's Space Junk Problem," *Nature*, September 5, 2018, 6, https://www.nature.com/.

[32] Duli Chand, Space Objects from All Countries (orbital objects dataset), Pacific Northwest National Laboratory, February 2023.

1. Orbit of the object
    i. Orbits of interest: low Earth orbit (LEO), highly elliptical orbit, or geostationary orbit
2. Velocities of the objects at apogee and perigee
    i. Calculating periapsis a: radius R of the Earth plus the perigee
    ii. Calculating apoapsis b: radius R of the Earth plus the apogee
    iii. Calculating the semi-major axis: $(a+b)/2$ where $a < b$
    iv. Vis-viva equation: $v^2=2GM(1/r - 1/(a+b))$ (here r is the distance of the satellite from the center of the earth to any point in the orbit)
    v. Velocity at perigee: $(r = a)$: $v_a = \sqrt{(2GMb/(a(a + b)))}$
    vi. Velocity at apogee: $(r = b)$: $v_b = \sqrt{(2GMa/(b(a + b)))}$
3. Spatial and temporal proximity of the orbital objects

As government, commercial, and science organizations launch more assets into space, space debris will inevitably increase in LEO, causing launch missions with the final destination of geosynchronous orbit to become increasingly more difficult. If using Bayesian networks in the DSS, space debris would be one of the threat nodes at the beginning of the decision tree that affects mission success.

By harnessing existing information from space object surveillance and identification programs and open-source space tracking sites like Space-Track.org, a DSS can ingest orbital trajectory data and combine it with data from other warfighting domains. Normally, combining datasets and results from multisourced intelligence sectors is the responsibility of the analysts; however, if a DSS can automate this process it allows the analyst to strategically forecast not only one decision, but also how that decision may affect other constellations or resources in another domain.

Space debris datasets include country designations which assist in identifying assets and debris from other countries. For example, the United States has the following breakdown of tracked objects in space: 9,430 debris; 7,267 payloads; and 1,490 rocket bodies. In comparison, Russia tracks 17,039 debris; 3,656 payloads; and 3,955 rocket bodies. Lastly, the PRC tracks 5,451 debris; 704 payloads; and 451 rocket bodies.

The United States, Russia, and China are responsible for most assets and debris in space. As competition increases, more assets in space will only create additional debris, especially as the Artemis I program and other cislunar projects commence in the next 5 to 10 years. Orbital debris is not the only threat; however, it affects all satellites and has implications for government, private, and other assets in space.

Antisatellite

In 2007, the PRC's first successful test of a kinetic physical ASAT destroyed an old PRC satellite system with a direct-ascent SC-19 missile system and created over 3,000 pieces of debris, of which roughly 2,800 are still in LEO around the earth.[33] Other examples of China's ASAT technologies include BX-1, which jettisoned as a small

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[33] Chand.

imaging satellite from Shenzhou; SJ-12, conducting rendezvous and proximity operations (RPOs) to test possible jamming/counterspace capabilities; and Aolong-1, which included a robotic arm.[34] One case of particular interest is SJ-17, a PRC communications satellite. SJ-17 launched in November 2016 and performed RPOs around communications satellite Chinasat 6A from June to July 2017. On July 1, 2017, SJ-17 came within 1.67 kilometers of Chinasat 6A and stayed within 15 kilometers until normalizing proximity on July 6, 2017.[35]

Satellites in geostationary orbit require authorization and reservation of orbital slots from the International Telecommunications Union (ITU), a specialized UN agency that assigns global radio frequencies to satellites to minimize interference with other satellites. A satellite operating outside its official ITU position could pose a threat to other satellites transiting that area.[36] Even though SJ-17 and Chinasat 6A are both PRC satellites, the signatures of two satellites moving close together and performing very close RPO maneuvers is of interest. Pushing proximity space norms may cause accidental collisions and unnecessary space debris, which will affect all satellites in the space domain.

In an effort to characterize how a DSS could model the threat of close RPO maneuvers, the National Intelligence University and Pacific Northwest National Laboratory pulled satellite telemetry data from Space-Track.org and built a model to characterize the orbital trajectories of SJ-17 and Chinasat 6A from May 2017 to December 2018.[37] After combining SJ-17 and Chinasat 6A's datasets, the team developed a Python program to create the upper limits and lower limits on each satellite's apoapsis and periapsis. Limits on the apoapsis and periapsis created zones for each satellite depending on the location in relation to the other satellite to identify aggressive orbital movements.

Since the ITU reserves orbital slots for each geostationary orbit satellite, there is a general location in the specified space within which the satellite should remain. Due to numerous factors, satellites usually have a "wobble" within their original ITU designation; however, that usually does not interfere with other satellites. When comparing both orbits of the satellite during the May to December 2017 time frame, the orbital data shows SJ-17 moving from its original ITU designation toward the Chinasat 6A satellite.

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[34] Brian Weeden and Victoria Samson, eds., *Global Counterspace Capabilities: An Open Source Assessment* (Broomfield, CO: Secure World Foundation, April 2022), 113, https://swfound.org/.

[35] Kaitlyn Johnson, "GEO Close Approach: SJ-17/Chinasat 6A," Satellite Dashboard, last updated January 28, 2022, https://satellitedashboard.org/.

[36] "Regulation of Satellite Systems," ITU [International Telecommunications Union], last updated February 2022, https://www.itu.int/.

[37] Chinasat 6A / SJ-17 datasets, Space-Track.org, March 2023, https://www.space-track.org.

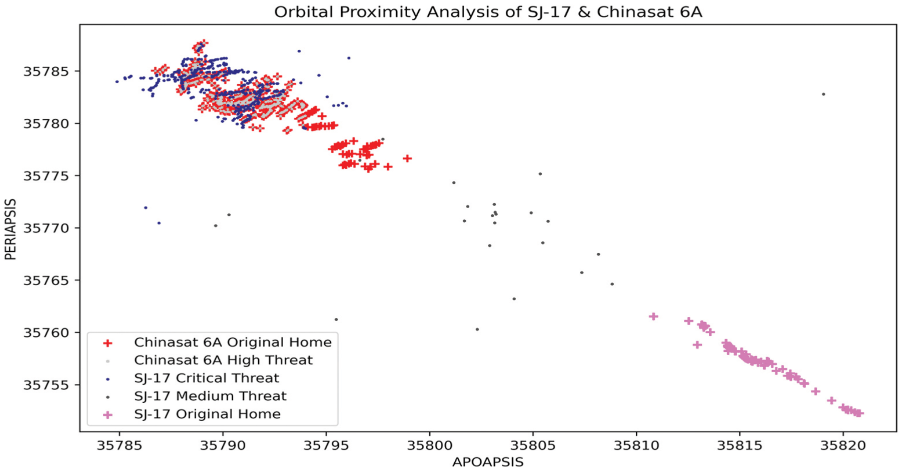

Figure 1. Orbital proximity analysis of SJ-17 and Chinasat 6A[38]

Additional data (2011 to present) with multiple space variables available from SJ-17 and Chinasat 6A will be used to further assess and test criticality and threats. The goal of this model is to identify when Chinasat 6A and SJ-17 are dangerously close and assign proximity scores based on their proximity to each other using their apoapsis and periapsis.

Organizations around the world already have similar capabilities to analyze satellite behavior. Since SJ-17's launch in 2016, there have been numerous abnormalities in its orbital trajectories. Figure 2 identifies anomalous SJ-17 orbital trajectories from 2016 to 2023 by analyzing the right ascension of ascending node (RAAN), which is the angle between the vernal equinox and the ascending node of the orbit. This is the point where the satellite passes from the southern hemisphere to the northern hemisphere.

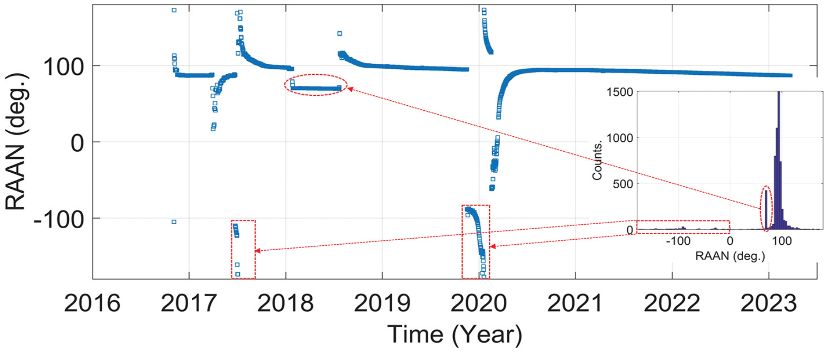

Figure 2. SJ-17 maneuvers between 2016 and 2023[39]

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[38] Danielle K. Ciesielski, SJ-17 & Chinasat 6A Proximity Threat Model, 2023.

[39] Duli Chand, Space Objects and SJ-17 & Chinasat 6A Analysis (orbital objects dataset), Pacific Northwest National Laboratory, February 2023.

Examples such as these draw alarm and have the potential to affect mission planning if similar aggressive positioning and anomalous orbits are deployed against competitor satellites. Mission planning and satellite adjustments take many days to start due to authorizations, analysis, and priority deconfliction. In comparison, a DSS using AI/ML statistical models and necessary inputs from subsystems could rapidly recalculate probabilities based on inputs from analysts or operators. By adjusting weighted values on assets, an analyst using the model could simulate aggressive behavior and offer predictions about the battlespace in advance of any aggressive act. This in turn would allow for wargaming-like scenarios based on real-time signatures and warnings, improving the ability to identify potential threats and vulnerabilities.

Electronic Warfare and Cyberattacks

Dickinson's 2022 Senate Arms Services Committee testimony highlighted cyber integration as a way to defend space mission systems and intellectual property while Space Command is implementing zero-trust architecture and AI/ML techniques to harden current and future systems.[40] Given today's cyber threats, it is paramount for ground, air, and space domains to prepare for cyberattacks to critical infrastructure.

Adversaries use satellite jammers, spoofers, laser dazzlers, and other forms of electronic warfare (EW) to influence or disrupt operations, with attribution being difficult in the space domain. Attributable real-world examples include Russia's jamming and spoofing of satellites to degrade drone operations in Syria, its jamming of GPS and satellites to disrupt Ukraine's satellite navigation and timing for radios since 2014, Moscow's periodic jamming of GPS signals in Norway and Finland during NATO exercises, and its spoofing of GPS signals in the Black Sea causing navigation errors.[41] These are a few examples of the reported cyberattacks on orbital assets, but each had a significant negative mission impact when considering the area of coverage for each system.

While SJ-17 performed RPO maneuvers around Chinasat 6A, it can be assumed EW actions such as jamming were deployed by SJ-17 against Chinasat 6A. Using this example, a binary "on" or "off" cyber or EW variable was added to the dataset, indicating if jamming was present during the RPO maneuvers. The proximity variable calculated in the previous ASAT criticality section characterized the proximity level on a scale of one to five, with five being close to each other, and one being far apart. Using this calculation, the cyber/EW variable was set to on for proximity levels with the value four and five, and the cyber/EW variable was set to off for proximity levels three to one.

This technique shows how to connect RPO maneuvers to possible jamming tactics. The combination of orbital trajectories, proximity variables, and cyber/EW data into one dataset is an example of how applied analytic models can characterize behavior in the space domain and create signatures for specific RPO maneuvers.

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[40] *NDAA for FY 2023*, 13.

[41] Melissa Dalton et al., *By Other Means Part II: Adapting to Compete in the Gray Zone* (Washington, DC: Center for Strategic and International Studies, August 2019), 20, https://csis-website-prod.s3.amazonaws.com/

Using these signatures, analysts can then continue to update the DSS statistical model with other threat reporting.

Conclusion

Decision support systems are essential for US space operations and during contingency planning to counter emergent threats against critical space infrastructure. The United States has an opportunity to harness existing taxonomies in information systems and address potential systemic biases by implementing a critical space infrastructure DSS. This system will assist in rapidly analyzing space threats, vulnerabilities, and capabilities for decision advantage. Implementing a DSS for space-domain threat analysis will allow operators and analysts not only to characterize threats, vulnerabilities, and capabilities of the space domain, but also to create a common body of knowledge where there is limited experience.

Implementing a DSS in the space domain will combat the lack of transparency and automation in the sector. The combination of inexperience, aggressive competitors, norms testing, and influence operations increases the likelihood of mistakes not only in the space domain, but also in the geopolitical environment. Building trust, coalitions, and common knowledge throughout the space community will enable senior-level decisionmakers throughout the US government to champion space topics at the highest levels. Through increased collaboration and research initiatives, the US government can employ the following strategy to realize a DSS that encompasses all current capabilities while increasing domain awareness. The government should:

- Deploy a national-level DSS in the space domain that ingests indicators, signals, and warnings from defense, private sector, and scientific space systems.
- Gather analyst, operator, and subject-matter-expert knowledge on characterizing space threats and incorporate this into the DSS.
- Build analytic tools to enable wargaming in the space domain. Operators and analysts should be able to set priorities, update weighted values for assets, create ad-hoc reports, and rapidly detect anomalous behaviors.

By collaborating with nation-state Allies and partners, commercial partners, and the scientific community, the US government will not only achieve decision advantage in the growing space domain, but also drive space policy and norms for the entire space community. As Artemis I and other space missions bring humanity back to the moon, the United States and its Allies and partners must harness emergent technologies for improved decision advantage. ***Æ***

DETERRENT AND DEFENSIVE APPLICATIONS OF ORBITAL ANTISATELLITE WEAPONS

Alexander Fiore

The United States and its Allies and partners face increasing threats in space from orbital antisatellite systems produced by Russia and China. US and Ally orbital antisatellite capabilities intended to deter aggression should be acknowledged in order to signal resolve and the threat of cost imposition. Simultaneously, the highly specialized subset of these systems to be used in defensive capacities benefits from continued classification, despite the fact this secrecy detracts from the deterrent effects of these systems.

The United States' access to and use of space is a vital national interest.[1] US, Ally, and partner space systems face increasing threats from Russian orbital antisatellite (O-ASAT) developments and Chinese dual-use systems on orbit. Presenting a full range of deterrent capabilities may require US Space Command to operate O-ASAT weapon systems to protect US, Ally, and partner space systems on orbit. This article presents an architectural approach for employing O-ASATs to produce a deterrent effect while preserving a defensive capability should deterrence fail.[2]

To dissuade potential adversaries from engaging in hostile acts in space, O-ASAT systems intended to deter aggression must be acknowledged to communicate resolve and the threat of cost imposition. At the same time, O-ASATs used to defend a broader space enterprise benefit from secrecy to reduce vulnerabilities and preserve the element of surprise, thus detracting from their deterrent effect.[3]

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[*] The author wishes to thank Dr. Gregory Miller, Major Brent Danner, and Wing Commander Clifford GSL Fletcher-Jones for their thoughtful comments and suggestions.

[1] White House, *United States Space Priorities Framework* (Washington, DC: White House, December 2021), 3, https://www.whitehouse.gov/.

[2] "From the Ultimate High Ground," US Space Command (USSPACECOM) (website), accessed September 7, 2023, https://www.spacecom.mil/.

[3] Gregory D. Miller, "Preventing War with a Warfighting Domain: Nuclear Deterrence Lessons for Space," *Astropolitics* 19, no. 1–2 (2021): 39, https://doi.org/.

If the United States employs O-ASATs for deterrent and defensive purposes, it must overcome the tensions between fielding overt O-ASATs for deterrence and keeping them secret to provide defensive capability. Addressing this problem for O-ASAT systems requires an architectural design incorporating space mission assurance (SMA) principles that "protect or ensure the continued function and resilience" of critical space capabilities and assets. Such an architectural design will deliver inexpensive, proliferated overt capabilities for deterrence through cost imposition, supported by highly technical, classified systems for defensive operations should deterrence fail.[4]

Deterrence and Defense: A Primer

Deterrence is "the manipulation of an adversary's estimation of the cost/benefit calculation of taking a given action."[5] In practice, the actor sending a deterrent message—the deterrer—attempts to convince an opponent that the perceived benefits of hostilities will be denied and met with unacceptable punishment such that the status quo is preferable.[6]

Deterrence by denial of benefit, accomplished through passive and active methods, involves convincing the opponent that the estimated probability of gaining their objective is insufficiently low or not worth the cost.[7] Deterrence through punishment or cost imposition acts on the aggressor's estimate of possible costs against what they value and may not affect their chances for gains.[8] In other words, cost imposition focuses on holding at risk what the opponent values and is countervalue in nature.

Deterrence is a psychological endeavor because it occurs in the opponent's mind.[9] For deterrence to work, the opponent must believe hostilities will be ineffective and counterproductive due to the perceived costs such that they withhold hostilities and preserve the status quo. The psychological element of deterrence requires the deterrer to communicate this idea to the opponent. Additionally, the opponent must believe not only that the deterrer is capable of denying benefits and imposing costs but also that the threats are credible, meaning that the deterrer will follow through on their commitment to retaliate and deny the benefits of initiating unwanted actions.[10]

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[4] Office of the Assistant Secretary of Defense for Homeland Defense & Global Security (OASD [HD&GS]), *Space Domain Mission Assurance: A Resilience Taxonomy* (Washington, DC: Department of Defense [DoD], 2015), 2, https://man.fas.org/.

[5] Austin Long, *Deterrence—From Cold War to Long War: Lessons from Six Decades of RAND Research* (Santa Monica, CA: RAND Corporation, 2008), 7, https://www.rand.org/.

[6] Karl Mueller, "The Continuing Relevance of Conventional Deterrence," in *Netherlands Annual Review of Military Studies 2020: Deterrence in the 21st Century—Insights from Theory and Practice*, ed. Frans Osinga and Tim Sweijs (Hague, Netherlands: T. M. C. Asser Press, 2021), 49.

[7] Glenn Herald Snyder, *Deterrence and Defense: Toward a Theory of National Security* (Princeton, NJ: Princeton University Press, 1961), 15.

[8] Snyder, 15.

[9] Mueller, "Continuing Relevance," 49.

[10] Robert P. Haffa, "The Future of Conventional Deterrence: Strategies for Great Power Competition," *Strategic Studies Quarterly* 12, no. 4 (2018): 96–97.

The concept of defense is a necessary component to credible deterrent threats but is distinct from deterrence. While deterrence focuses on preventing unwanted activity, such as war, defense focuses on responding to such activity. The goal of deterrence is typically to delay the onset of war indefinitely; the goal of defense is to win the war and minimize the damage to one's side. Defense is thus the reduction of future costs and risks if deterrence fails. Defensive capabilities are used to resist attack and mitigate or prevent war damage, including in some cases to maximize friendly gains.[11] Such capabilities are counterforce in nature because they focus on countering an opponent's attacking forces and resisting their ability to inflict damage.

Deterrence and defense have distinct but related goals that manifest before and after an unwanted action, respectively. Therefore, strategies for achieving each concept present different objectives. Efforts to enhance deterrence are centered on peacetime objectives, whereas defensive activities provide a wartime value.[12] Because deterrence occurs in an opponent's mind before their decision to attack and requires communicating the credible use of capable forces, this presents a dilemma for defensive forces that benefit from the element of surprise to maximize their effectiveness and reduce vulnerabilities to those capabilities.

Activities to enhance deterrence can detract from defensive capabilities and vice versa due to the tension between conveying the credible use of forces and preserving reliable options to counter an attack. Additionally, some forces are better suited to produce deterrent effects, though they do not provide an effective denial and damage-alleviating capability.[13] Finally, deterrence by threat of cost imposition is not focused on the direct defense of the forces in question. Instead, it threatens the broader punishment of an adversary, raising the cost of an attack.[14]

Deterrent forces designed for cost imposition against countervalue targets may not be suited for counterforce targets necessary to resist an attack. For example, nuclear weapons as a countervalue implement may impose tremendous costs on an adversary's cities but do little to defend against an incoming salvo of nuclear weapons in kind.[15]

On the other hand, defensive capabilities focused on counterforce targets required to resist attack and mitigate war damage may do little to deter aggression if they cannot inflict satisfactorily high costs on an opponent. Antiaircraft artillery may resist strategic bombers but would be mild deterrents by their inability to impose high costs on an adversary's assets outside the artillery's defensive reach.

This tension requires simultaneously considering the reduction of the probability of war through deterrence and mitigating its consequences through defensive measures. As this analysis suggests, to field effective forces designed to create a deterrent effect before the war and defensive capabilities at the onset of war requires a blend of

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[11] Snyder, *Deterrence and Defense*, 3–5.

[12] Snyder, 4.

[13] Snyder, 4.

[14] Michael J. Mazarr, "Understanding Deterrence," in *Netherlands Annual Review*, 16.

[15] Snyder, *Deterrence and Defense*, 6.

attributes applied to a nation's military forces.[16] These attributes must provide cost imposition via countervalue strategies communicated to an opponent as capable and credible while maintaining defensive counterforce capabilities that reduce vulnerabilities and retain the element of surprise to resist attack if deterrence were to fail.

The US Deterrence Strategy

The *National Security Strategy* pursues deterrence through an integrated approach. Integrated deterrence combines all instruments of US national power with Allies' and partners' capabilities across all domains and theaters during peace, competition, and armed conflict to dissuade potential adversaries from hostile activities.[17] Integrated deterrence seeks to demonstrate to an adversary that the United States' combined strengths and capabilities present unacceptable costs outweighing the benefits of the adversary's pursuit of conflict.

Central to this approach is the flexibility of options it provides US leadership by working across all instruments of national power, including military, informational, diplomatic, financial, intelligence, economic, legal, and developmental together with Allies and partners. Integrated deterrence allows the United States to shape adversary perceptions of risks and costs of actions, at any time and across any domain.[18]

The *National Defense Strategy* articulates how the Department of Defense will pursue deterrence by utilizing all domains acting together. The strategy articulates three ways to organize deterrent effects: deterrence by denial, deterrence by resilience, and deterrence by direct and collective cost imposition.[19] Using integrated deterrence, the strategy implements denial of benefit through the imposition of costs by leveraging all available branches and domains. For example, an attack against US and Allied space systems can be deterred by denying the benefit of attack through resilient systems while presenting the threat of retaliation—cost imposition—within any domain. Fielding O-ASATs could complement deterrence by cost imposition within the space domain by increasing the availability of options to US leaders' integrated deterrence strategy.

Deterring and Defending in Space

The United States requires access to and use of space to enable its way of life. Critical infrastructure for national security, the economy, transportation, science, technology, and other sectors rely on space-based capabilities.[20] Therefore, the Department of

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[16] Snyder, 4–5.

[17] Joseph R. Biden Jr., *National Security Strategy* (Washington, DC: White House, October 2022), 22, https://www.whitehouse.gov/.

[18] Biden, 20; and Chairman of the Joint Chiefs of Staff (CJCS), *Strategy*, Joint Doctrine Note (JDN) 1-18 (Washington, DC: CJCS, April 25, 2018), viii, https://www.jcs.mil/.

[19] Lloyd J. Austin III, *2022 National Defense Strategy of the United States of America* (*NDS*) (Washington, DC: DoD, October 2022), 8, 9, https://media.defense.gov/.

[20] White House, *Space Priorities Framework*, 3, 6.

Defense recognizes space as a vital US national interest.[21] The *Defense Space Strategy*, subordinate to the *National Defense Strategy*, addresses deterring adversary attempts to degrade US critical infrastructure and defending against the hostile use of space. The space strategy requires the United States to protect and defend Ally, partner, and commercial space capabilities.[22]

Role of US Space Command

Within the Department of Defense, US Space Command is tasked with the protection and defense of US space assets. In particular, it "plans, executes, and integrates military spacepower into multi-domain global operations to deter aggression, defend national interests, and when necessary, defeat threats."[23] Given the command's area of responsibility of 100 kilometers above mean sea level, it is uniquely poised to command and control the use of O-ASAT weapon systems should they one day be fielded.[24]

Space Force and Deterrence

The US Space Force leads the development of space system architectures provided to Space Command, thus providing deterrence methods relevant to the command's strategy. Its perspective on integrated deterrence is captured in the Space Force Strategy Note, *Integrated Deterrence*. The strategy note is a primer for strategic Space Force topics and is not considered an authoritative document.[25] Yet it highlights considerations for military space forces from the perspective of the Space Force chief of strategy and resources.[26]

Implications from the strategy note are drawn from the integrated deterrence concept of the *National Security Strategy* and *National Defense Strategy* and apply the space mission assurance framework to achieve denial of benefit from attack. The framework outlines mechanisms for denial of benefit and constitutes deterrence insofar as this framework is successfully communicated and interpreted by an opponent as credible and capable enough to deny sufficient benefits of a prospective attack. As the strategy note states, "Any space mission assurance efforts must be widely publicized and demonstrated in order to be effective in dissuading others."[27]

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[21] Austin, *NDS*, 5.

[22] DoD, *2020 Defense Space Strategy Summary* (Washington, DC: DoD, 2020), 2, https://media.defense.gov/.

[23] USSPACECOM, "Ultimate High Ground."

[24] *Hearing on U.S. Strategic Command and U.S. Space Command in Review of the Defense Authorization Request for Fiscal Year 2023*, 118th Cong. (2022) (statement of General James H. Dickinson, commander, USSPACECOM), 12, https://www.armed-services.senate.gov/; and CJCS, *Joint Space Operations*, Joint Publication (JP) 3-14 (Washington, DC: CJCS, 2023), 1-2.

[25] US Space Force (USSF), *Integrated Deterrence*, Space Force Strategy Note 1-23 (Washington, DC: USSF, February 6, 2023), 0.

[26] USSF, 1.

[27] USSF, 6.

The space mission assurance framework articulates the denial of benefit through three approaches: defensive operations, reconstitution, and resilience. Defensive operations provide space domain awareness for warning and counterforce systems for defense.[28] Reconstitution replenishes lost functions after an attack or catastrophic event, exemplified by rapid launch and the establishment of new ground stations when needed. Resilience is "the ability of an architecture to support the functions necessary for mission success . . . in spite of hostile action."[29]

Resilience methods are subdivided into six categories: disaggregation, distribution, diversification, proliferation, protection, and deception. Disaggregation separates capabilities onto different platforms so that the effect of losing one platform does not result in multiple mission impacts. Distribution is accomplished by using various distributed nodes working together as a single node to reduce the effect of any node's loss. Diversification uses a variety of sources, payloads, and partners in different orbits to contribute to the same mission.

Proliferation is achieved through quantities of scale where contributions of many copies of the same platform, payload, or system accomplish a mission. Protection includes onboard active and passive countermeasures to mitigate and deny adverse effects to missions. Finally, deception requires hiding the strengths and weaknesses of capabilities to reduce an opponent's ability to anticipate and counter that capability.[30] Incorporating principles of space mission assurance into Space Force space system architectures can aid US Space Command's ability to deter through the denial of benefit.

The strategy note does not discuss implications for establishing deterrence by cost imposition but does state that "significant defensive and offensive space capabilities may dissuade others from attempting to compete in space."[31] This implies the inclusion of counterforce systems for defense and countervalue systems for offensive operations may be required to fully complement a deterrence strategy by cost imposition.

Deterrence and Defense in the Competition Continuum

The US military operates under a spectrum of conflict known as the competition continuum, "a world of enduring competition conducted through a mixture of cooperation, competition below armed conflict, and armed conflict."[32] Effective deterrence during competition below armed conflict can prevent a transition to armed conflict.[33] Space Command, employing Space Force and other military space systems on orbit, must contribute to integrated deterrence below armed conflict and to defense in armed conflict.

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28. OASD (HD&GS), *Space Domain*, 3.
29. OASD (HD&GS), 3.
30. OASD (HD&GS), 6–8.
31. USSF, *Integrated Deterrence*, 6.
32. CJCS, *Competition Continuum*, JDN 1-19 (Washington, DC: June 3, 2019), 2, https://www.jcs.mil/.
33. CJCS, 5–6.

O-ASATs in Deterrence and Defense

US Space Command may be required to enhance deterrence by direct and collective cost imposition in the space domain. O-ASATs could achieve this as part of a broader integrated deterrence strategy. This strategy would be suited for deterring an adversary that valued their space systems by complicating their cost-benefit calculations before they initiate armed conflict. Fielding orbital space weapons for a cost imposition deterrence strategy would require their general capabilities to be communicated in some capacity that conveyed the message to an opponent that the weapons could inflict high costs and that the United States would credibly use them. The command may also require O-ASATs designed to provide a counterforce component to fulfill the defensive operations element of space mission assurance for the space enterprise.

O-ASATs, like satellites with traditional space missions, are subject to the characteristics of the space environment. The satellites' propellant required to maintain their position and attitude or adjust their orbits is not currently refreshed and constrains their operational life and orbital regimes. Once satellites are placed in an orbital regime, such as low Earth orbit, highly elliptical orbit, or geosynchronous orbit, they are generally confined to those orbits. Due to their limited maneuverability, observers on the ground can track satellites and predict their orbits. States without tracking equipment can purchase satellite tracking data commercially, and US Space Command publishes tracking data at Space-Track.org.[34] Military and intelligence satellites maintain levels of secrecy to obscure mission details. Still, their general purposes can be inferred based on the orbits they are placed in and the characteristics of their radio emissions.[35]

O-ASATs must contend with these realities that challenge their durability as a deterrent threat. Durability consists of survivability, resilience, and sophistication.[36] Survivability relates to the opposing nations' knowledge of satellites' predicted orbits through their space-tracking capabilities. Further, many countries can disrupt, degrade, and destroy satellites with kinetic and nonkinetic means.[37]

China, Russia, and India have ground-based direct-ascent ASAT missiles capable of targeting and destroying satellites.[38] Threats exist on orbit, as demonstrated by Russia's tests of an O-ASAT near a US national asset beginning in 2019.[39] China has fielded an orbital servicing platform in geosynchronous orbit with dual-use capabilities

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[34] Defense Intelligence Agency (DIA), *Challenges to Security in Space, Space Reliance in an Era of Competition and Expansion* (Washington, DC: DIA, 2022), 43, https://www.dia.mil/; and Login page, Space-Track.org (website), accessed September 21, 2023, https://www.space-track.org/.

[35] Air Command and Staff College (ACSC) Schriever Space Scholars & Air War College (AWC) West Space Seminar, *AU-18 Space Primer* (Maxwell AFB, AL: Air University Press, 2023), 19, https://www.airuniversity.af.edu/.

[36] Miller, "Preventing War," 38.

[37] Miller, 40.

[38] Todd Harrison et al., *Space Threat Assessment 2022* (Washington, DC: Center for Strategic and International Studies [CSIS], 2022), 3, https://csis-website-prod.s3.amazonaws.com/.

[39] DIA, *Challenges to Security*, 29; and W. J. Hennigan, "Exclusive: Strange Russian Spacecraft Shadowing U.S. Spy Satellite, General Says," *Time*, February 10, 2020, https://time.com/.

that could be operated nefariously as an O-ASAT.[40] Other nations possess the ability to jam and lase satellites, causing various levels of degradation to satellite systems.[41]

Satellites generally cannot return to a secure base or hide in a hangar until an opportune moment for deployment. Though a spaceplane can be protected on the ground and transit between the Earth and space, it requires a rocket launch that is generally restricted to a few locations potentially vulnerable to conventional strikes, eliminating its effectiveness in space if not already on orbit. Additionally, timelines necessary to respond to threats in orbit may be shorter than launching in a crisis, thus detracting from a spaceplane's ability to provide a counterforce capability. Further, conducting a launch precludes the element of surprise, and a spaceplane must also contend with survivability considerations once in orbit.

Resilience, referred to as weapon potency, describes the extent to which an opponent can nullify a weapon system once employed and remain effective as a deterrent or defense once revealed.[42] If an O-ASAT system has a limited magazine depth, it must be refreshed once used.[43] If an O-ASAT's capability is predicated on its secrecy, it does not provide a deterrent effect. If its capability depends on the element of surprise, then it suffers as a defensive measure once revealed.

The level of sophistication a space weapon possesses contributes to its ability to deter. If an opponent can copy the weapon system, it can be used against the deterrer. This factor encourages the deterrer to hide its capability for defense, thus nullifying the deterrent effect of that space weapon.[44]

Achieving a deterrent effect with O-ASATs requires they be communicated to an opponent as capable and their implementation credible. This provides a dilemma for a singular capability that opponents can target to counteract and duplicate, reducing its deterrent and defensive strength once revealed.[45] The solution to overcome obstacles of O-ASAT system durability is to identify an architecture of systems that achieve deterrent and defensive effects through different approaches that complement each other.

O-ASATs and Space Mission Assurance

The SMA framework provides principles to enhance the denial of benefit and thus improve survivability attributes within an O-ASAT's architecture. For example, the Space Force could develop multiple types of capabilities and reveal some of them, reducing their element of surprise to communicate a capability for deterrence while reserving other capabilities to maintain defensive options in the outbreak of war.[46] Fielding multiple types of O-ASAT systems could achieve the principles of defensive

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[40] DIA, 18.

[41] DIA, 17, 28; and Harrison et al., *Space Threat Assessment 2022*, 10, 21, 33.

[42] Miller, "Preventing War," 41.

[43] Miller, 42.

[44] Miller, 43.

[45] Miller, 39.

[46] Miller, 52.

operations, reconstitution, and resilience, thereby providing options for deterrence and defense while minimizing the effects of survivability, potency, and sophistication.

Two satellite developmental approaches to O-ASATs, when combined, can achieve SMA principles: inexpensive assets in large quantities and highly specialized assets in smaller quantities. Inexpensive assets are typically small and fulfill a limited range of capabilities. Their strength is in their high numbers and ability to work as a broader architecture to accomplish a defined mission set. Owing to their lower costs, inexpensive assets are best suited for reconstitution and proliferation strategies.

Highly specialized assets primarily focus on delivering superior capabilities, requiring enhanced technical sophistication. As a result, each satellite is typically more expensive and individually more capable than inexpensive assets for a defined mission. These systems are costly to proliferate and therefore better served by onboard protections that enhance their survivability but add weight and additional cost. Finally, these systems are appropriate for deception tactics because their lower numbers more easily obscure their purposes and capabilities.

Architectures can use both approaches to achieve elements of disaggregation—spreading their specific effects across the constellation, distribution—enabling them to work together by sharing data to accomplish their missions, and diversification—placing assets in different orbits to complement each other. The United States' missile warning satellite systems aim to achieve this architectural design of combining the two approaches using specialized systems like the Space-Based Infrared System (SBIRS) coupled with the proliferation of Tranche 0 and Tranche 1 satellites developed by the Space Development Agency.[47] This constellation of satellites achieves resilience through proliferation and diversification, allowing its mission to endure disruption to one of its satellites.

Achieving deterrence through denial of benefit and cost imposition while preserving defensive capabilities with O-ASATs requires the two types of system designs be pursued simultaneously. Inexpensive O-ASATs are suitable for overtly communicating a countervalue capability to an opponent. Yet they are more challenging to conceal, resulting from the large quantities required for their resilient attributes. By contrast, highly technical, specialized systems are easier to keep secret due to their fewer numbers and are more capable of fulfilling a counterforce role against adversary O-ASATs should a conflict break out.

Both approaches require their effects and capabilities to be measured by different standards, those of counterforce and countervalue, so combining them provides an aggregate utility to the architecture.[48] Both approaches seek to maximize a deterrent

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[47] Sandra Erwin, "L3 Harris to Deliver Five Missile-Warning Satellites for 2023 Launches," *SpaceNews*, July 27, 2022, https://spacenews.com/; US Government Accountability Office (GAO), "Missile Warning Satellites: Comprehensive Cost and Schedule Information Would Enhance Congressional Oversight," GAO (website), September 22, 2021, https://www.gao.gov/; and DoD News, "Space Development Agency Successfully Launches Tranche 0 Satellites–Space Development Agency," Space Development Agency (SDA), April 2, 2023, https://www.sda.mil/.

[48] Snyder, *Deterrence and Defense*, 5.

capability while preserving and enhancing a defensive one by leveraging the principles of space mission assurance.

O-ASATs for Defensive Value

Highly specialized O-ASATs focused on delivering the most effective capabilities are appropriate for the counterforce role. These systems can be designed to maintain the element of surprise and can provide the greatest effects to contend with the most capable adversary O-ASATs. To preserve their survivability, weapon potency, and sophistication while maintaining the element of surprise, these systems and their capabilities should be closely guarded and kept secret, thus protected from adversary copying.[49] The systems could field nonkinetic weapons to increase their magazine depth to mitigate weapon potency concerns—preventing the system from being nullified after use.[50]

These O-ASATs are likely the most expensive due to the premium placed on providing capability. Owing to their cost, these systems would be constrained to a relatively small constellation, reducing their ability to rely on proliferation or reconstitution for survivability. Such systems could instead depend on protection measures, although this would add to their costs per unit. Highly advanced O-ASATs would also depend on deception and could be hidden through various means, such as posing as benign satellites in peacetime. Obscuring a satellite's true purposes would be challenging at scale and would therefore be suited to low-density constellations.

These O-ASATs could fulfill the defensive operations component of space mission assurance's denial-of-benefit principles for the broader space architecture by providing counterforce capabilities to resist attacks from adversary O-ASATs. These capabilities would not directly contribute to deterrence by denial of benefit. But if armed conflict broke out and highly developed systems successfully denied an attacker after deterrence failed, this denial could deter an opponent from risking future hostilities.[51]

If selectively revealed prior to the start of hostilities, they may also provide an immediate deterrence role in situations transitioning from below-armed conflict into armed conflict by complicating adversary planning. This strengthens the perception by the adversary of the overall architecture's capability, despite introducing additional vulnerability by compromising the element of surprise.

Along with the stated benefits, secret, highly specialized O-ASATs present drawbacks that extend beyond their limited deterrent role. They are less likely to be used during competition below armed conflict because revealing them presents disadvantages to their defensive value. Their highly classified nature presents barriers to integrating and exercising these systems with international partners. Low numbers of highly classified systems would be expected to result in a smaller cadre of trained

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[49] Miller, "Preventing War," 44.

[50] Miller, 41–42.

[51] Miller, 44; and Snyder, *Deterrence and Defense*, 32.

personnel to operate them and to develop tactics, techniques, and procedures (TTPs) for their implementation, which may also reduce their effectiveness in war. Finally, the nature of their classification makes it more difficult to partner with industry to incorporate new solutions from smaller companies that may not possess the classified accesses required. Moreover, such companies may also be excluded due to higher costs resulting from tighter security measures.

O-ASATs for Deterrent Value

Deterrence by cost imposition in space using an O-ASAT system requires the ability to communicate a countervalue capability that satisfactorily overcomes the challenges of survivability, weapon potency, and sophistication to an adversary who also deems their use credible. Overt inexpensive O-ASATs scalable to large quantities focused on a countervalue mission are appropriate for in-space options to provide deterrence through cost imposition. These systems enhance US messaging options within the competition continuum, especially below the level of armed conflict, that do not reveal their most sensitive capabilities. Further, these systems provide a countervalue benefit during armed conflict by disabling critical supporting military satellites in times of war. Overt O-ASATs facilitate increased numbers of personnel trained on their capabilities and allow greater collaboration with Allies and partners.

Communication

An adversary must value the continued existence of its space systems in order for countervalue-capable O-ASATs to have a deterrent effect. Moreover, credible communication through public announcements, messaging, and demonstrations of capabilities through exercises and testing help ensure the countervalue capability is taken seriously and incorporated into an adversary's cost-benefit calculations as they consider initiating hostilities.[52]

Overt systems would enable US Space Command to respond to challenges on orbit within the competition continuum, especially during situations below armed conflict. For example, friendly O-ASATs can escort an adversary O-ASAT out of a defined keep-out zone like a fighter aircraft escorts intruding aircraft out of its airspace. Russia demonstrated an O-ASAT capability in 2020 with its test of Cosmos 2543 near a US satellite.[53] With an overt capability, the United States could respond to close approaches from O-ASATs—an example of an aggressive action below armed conflict—to communicate credible resolve and consequences within the space domain. Overt O-ASATs provide Space Command the ability to communicate through actions on

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[52] USSF, *Integrated Deterrence*, 4, 5; and Stephen L. Quackenbush, "Deterrence Theory: Where Do We Stand?," *Review of International Studies* 37, no. 2 (2011): 761.

[53] DIA, *Challenges to Security*, 29; and Hennigan, "Strange Russian Spacecraft."

orbit that unacceptable behavior will be opposed and send a message of strong normative disapproval.[54]

Capability

Capabilities of overt O-ASAT systems would primarily be intended to hold adversary military-supporting satellites at risk, including satellite communications; intelligence, surveillance, and reconnaissance; position, navigation, and timing; and others. These military-supporting satellites generally have limited protections and maneuverability, making them ideal targets for inexpensive O-ASATs and less susceptible to weapon potency concerns resulting from their target's limited defenses. Therefore, the capability of an O-ASAT to target an adversary military-support satellite is not diminished by the general awareness of the O-ASAT's weapon's capabilities. Additionally, incorporating reconstitution as a strategy for space mission assurance refreshes the weapon potency of the constellation.

Inexpensive O-ASAT systems would rely on SMA principles of reconstitution and proliferation to enhance their survivability. Simultaneously, secretive O-ASAT systems provide qualities of disaggregation, distribution, and diversification across an integrated architecture that achieves denial of benefit from attack.

The proliferation of inexpensive overt O-ASATs enhances deterrence by complicating adversary decision calculus and increasing demands on their targeting during armed conflict. These systems affect adversary risk assessments by increasing the anticipated costs for any potential aggressor during hostilities.[55] Proliferating these relatively inexpensive systems complicates an adversary's cost-benefit calculation by driving complexity and making countering multiple targets more expensive. In addition to increasing the monetary costs of a potential attack, an attack against high numbers of O-ASATs risks escalation, denying a low-risk fait accompli.[56] Fielding overt O-ASATs presents the adversary with greater burdens, complicating a first strike by shifting an adversary's focus from targeting friendly, expensive supporting satellites required for a terrestrial conflict toward countering relatively inexpensive assets.

Deterrence commitments made by inexpensive O-ASATs will be less effective if they can be countered, but the deterrer does not need to prove they can defeat the opponent if they can convince the opponent that sufficient costs would outweigh the opponent's prospective gains.[57] An adversary may field O-ASATs that are superior in capability to the friendly inexpensive O-ASATs, detracting from the inexpensive weapons' ability to deter attack. Still, adversary O-ASAT systems must also overcome survivability, weapon potency, and sophistication challenges that can be exploited by fielding more capable secretive systems in reserve. By blending the two

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[54] Patrick M. Morgan, "Taking the Long View of Deterrence," *Journal of Strategic Studies 28*, no. 5 (2005): 755.

[55] Mazarr, "Understanding Deterrence," 19.

[56] Mazarr, 20.

[57] Miller, "Preventing War," 35.

approaches, overt and secret, the denial of benefit from attack can be achieved even if deterrence fails.

O-ASAT capabilities are enhanced by introducing overt assets that permit greater contributions to TTPs and military expertise. Revealing O-ASATs and relieving barriers presented by classification allow for a broader cadre of military units to participate in exercises and TTP development and to contribute to doctrinal philosophies on their use. General B. Chance Saltzman, chief of space operations for the US Space Force, has emphasized the necessity of increasing combat credible forces:

> A ready force has the training, tactics, and operational concepts required to accomplish the mission across the spectrum of operations—from competition to high-intensity conflict. A combat-credible force has the demonstrated ability to execute and sustain operations in the face of a determined adversary.[58]

Training with and exercising overt O-ASATs strengthens the overall military thinking and combat credibility of the units assigned to those systems. Additionally, these military professionals can apply lessons learned in exercises and TTP development to enhance defensive applications of secret O-ASAT systems. By fielding assets available for exercising and teaching general theory related to their use, overt O-ASATs bolster the knowledge base and requirements for more capable, overt, and secretive systems. This effect strengthens O-ASAT deterrence value by demonstrating a combat-credible team of military professionals trained to outthink an adversary.

Credibility

Space weapon systems may be among the first options to employ as tensions escalate toward armed conflict because they do not directly result in the loss of life. O-ASAT systems have narrow mission sets focused on disabling, disrupting, degrading, and destroying other satellites. The use of overt O-ASAT systems can instill credibility through their limited effects and lack of collateral damage.

Overt O-ASATs present the ability for the United States to incorporate Allies and partners within exercises and messaging strategies. Working with Allies and partners is central to the *National Security Strategy*, *National Defense Strategy*, and US Space Command strategies.[59] Exercising O-ASAT systems and demonstrating their general use cases can message to an adversary that the United States and its partners are prepared to respond to hostilities and give an impression of how that response might manifest. This adds credibility as the United States works with its Allies to exercise various contingencies and message potential responses to actions they deem unfavorable.

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[58] Greg Hadley, "To Deter in Space, US Needs Resilience—and an 'Offensive Threat,' " *Air & Space Forces Magazine*, April 6, 2023, https://www.airandspaceforces.com/.

[59] Biden, *National Security Strategy*, 11; Austin, *NDS*, iv; and Dickinson, statement, 3.

Additional Deterrence Considerations

Incorporating overt O-ASATs into US, Allied, and partner exercises and operations to achieve a legitimate deterrent effect can aid the development of international norms. The international adoption of normative behavior in space can reduce hostilities and the role of deterrence as the only means to dissuade unwanted actions. Norms establish regular behavior patterns and limit accidental interference and ambiguous activity.[60] As one analysis notes, in the absence of established internalized norms, deterrence socializes and helps educate actors by sending strong signals of normative disapproval. The existence of norms is confirmed and reinforced by actions to enforce them when violated.[61]

Norms are underwritten by deterrence associated with the threat of cost imposition, thereby increasing their effectiveness. Overt O-ASATs commanded by US Space Command can provide credibility for intervention when norms are violated. Yet as the analysis further contends, deterrence is most effective when employed in support of norms widely regarded as legitimate.[62]

Arms Race in Space?

The United States may receive criticism for fielding overt O-ASATs by advancing a perception that they may lead to an arms race in space.[63] Yet, Space Command is responsible for deterring threats from Russian O-ASAT developments and Chinese dual-use satellites while taking steps to defend against them. The command could pursue an approach that maintains its ability to deter and defeat threats that minimize the acceleration of an arms race in space to respond to threats. Such a strategy would enable the command to moderate the speed at which it reveals capabilities to match an adversary. Adopting a blended architecture of proliferated overt O-ASATs and secret O-ASATs would allow Space Command to manage the capabilities it displays to an adversary on orbit for deterrence while reserving capabilities for defense.

Deliberately revealing capabilities at parity with or, in some cases, inferior to an adversary can slow the dynamics of an arms race while preserving its greatest capabilities in secret. If an adversary adopts a similar strategy of proliferating O-ASATs, the command may choose to reserve its most capable O-ASATs to contend with those threats. By revealing O-ASAT capabilities, US Space Command's partnership with Allies could also demonstrate the responsible use of O-ASAT systems to contribute to developing normative behavior. Space Command and Allied demonstrations of normative behavior could create an environment that reduces the dynamics of a security dilemma created by the perception of an arms race in space.

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[60] Martha Finnemore and Kathryn Sikkink, "International Norm Dynamics and Political Change," *International Organization* 52, no. 4 (1998), 894.

[61] Morgan, "Taking the Long View," 761.

[62] Morgan, 755, 760–61, 763.

[63] Miller, "Preventing War," 44.

Conclusion

As part of a broader US integrated deterrence strategy, US Space Command may choose to employ O-ASAT weapon systems. Yet the command must simultaneously deter hostilities and prepare to defend its satellites from adversary O-ASATs. An architecture of O-ASAT systems can operate throughout the competition continuum, yet singular O-ASAT systems are susceptible to durability challenges from survivability, weapon potency, and sophistication concerns.[64] This incentivizes maintaining secrecy to preserve defensive value while detracting from these systems' deterrent effects.

A solution to this dilemma involves operating overt and secretive systems within an architecture of O-ASATs that implements principles of space mission assurance to overcome durability challenges.

Secretive systems may require extremely technologically advanced capabilities that will increase their costs, resulting in lower numbers of assets suited to protection and deception methods for survivability. Yet these O-ASAT systems are critical assets in the event of active hostilities. Overt O-ASATs and the broader space enterprise should be defended by these classified, specialized O-ASAT systems designed to provide counterforce capabilities reserved for armed conflict.

Working in conceptual concert with classified systems, overt O-ASAT systems strengthen deterrence through countervalue cost imposition by communicating a capable and credible threat. These systems enable US Space Command to improve its space professionals' warfighting abilities and incorporate Allies and partners into exercises and operational planning. Overt O-ASATs should be fielded as inexpensive systems suited for proliferation and reconstitution. Overt and secretive O-ASAT systems operated within an architecture incorporating principles of space mission assurance can allow US Space Command to employ deterrent and defensive capabilities on orbit. **Æ**

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[64] Miller, 39.

TERRESTRIAL RESPONSES TO SPACE AGGRESSION

Ron Gurantz

Deterring aggression in the space domain by targeting space-based assets or space-related ground assets may be ineffective or have adverse consequences, such as the increase of space debris. The United States should instead consider other terrestrial targets, but the main challenge is identifying such retaliatory targets outside of space. Without an obvious relationship between space and the target, retaliation would send the wrong message and could be escalatory. One way to solve this problem is for the United States to create a symbolic relationship between space aggression and terrestrial targets. This article explores how a shift in terms and shared perceptions concerning space assets may help in deterring adversarial actions and what challenges such a shift might produce. Rather than offer specific recommendations, this article highlights the importance of symbolism in deterrence.

In June 1993, the United States responded to a foiled Iraqi assassination attempt against former President George H. W. Bush with missile strikes against the Iraqi Intelligence Service headquarters in downtown Baghdad. Evidence pointed to a group of individuals allegedly hired by the Iraqi Intelligence Directorate, or Mukhabarat, in the plot to kill Bush. When asked why the Mukhabarat building was chosen as the target, Chairman of the Joint Chiefs of Staff Colin Powell explained it was the "closest thing to the provocation" and the "nexus to the provocation."[1] He did not explain what linked the building to the provocation, but the target was not selected to accomplish the typical military goal of reducing the enemy's strength or capabilities. Although the target was the home of the agency that carried out the operation, the missile strike probably did little to degrade Iraq's capacity for future operations.

Instead, the relationship between the provocation and the retaliation is best described as symbolic. The United States decided, in the words of theorist Thomas Schelling, "to respond in the same language, to make the punishment fit the character

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[1] Michael Knights, *Cradle of Conflict: Iraq and the Birth of the Modern U.S. Military* (Annapolis, MD: US Naval Institute Press, 2005), 143.

of the crime, to impose a coherent pattern on relations."[2] There is no hard-and-fast rule about what constitutes responding in the same language, but it was obvious the target was connected to the assassination attempt.[3] Other targets could have imposed the same level of punishment on the Iraqi government, but they would not have seemed as appropriate or have held the same meaning.[4]

The same instinct for retaliation to be directed at the nexus to the provocation is apparent in discussions about responding to attacks against satellites. Studies on space defense usually begin by mentioning retaliation in the space domain, only to reject this option later.[5] As an alternative, some have proposed striking the enemy's space-supporting ground stations.[6] In both cases, the proposed target is either in space or has some relationship to space. This is not a carefully reasoned thing, but the intuition is not wrong. Any identified target probably does require some relationship to the initial attack to be considered appropriate for retaliation.[7]

The default to either space-based or space-related targets is problematic for several reasons. The main concern is that enemies are likely to attach more value to destroying American satellites than preserving their own. Thus the threat to deny an enemy the use of their satellites may not be enough to deter. This leaves strategists at an impasse. There does not seem to be a response to space aggression that not only targets the nexus to the provocation but also delivers sufficient pain to deter attacks. The United States may not want to respond in space for other reasons: to avoid normalizing attacks in space, creating fields of orbiting debris that endanger other satellites, or being misinterpreted by states with poor space surveillance capabilities.

One solution for deterrence in space is the creation of a symbolic relationship between space aggression and a specific retaliatory action. In the absence of an obvious response that is the nexus to the provocation, the United States has to define the nexus for other nations. This requires convincing other countries that there is a relationship between satellites and a terrestrial target, or between a space action and a terrestrial action, that was not previously considered space-related. The symbolic relationship could be based on any number of factors, as long as it is widely understood and accepted.

Symbolism is an important consideration in retaliation. Although political and military leaders may not use the language of symbolism, they are using symbolic logic

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[2] Thomas C. Schelling, *Arms and Influence* (New Haven, CT: Yale University Press, 2020), 149.

[3] Knights, *Cradle of Conflict,* 141–43.

[4] Schelling, *Arms and Influence,* 145.

[5] Roger G. Harrison, Deron R. Jackson, and Collins G. Shackleford, "Space Deterrence: The Delicate Balance of Risk," *Space and Defense* 3, no. 1 (Summer 2009), 22–25; James P. Finch and Shawn Steene, "Finding Space in Deterrence," *Strategic Studies Quarterly* 5, no. 4 (2011): 14; and Forrest E. Morgan, *Deterrence and First-Strike Stability in Space* (Santa Monica, CA: RAND Corporation, 2010), 28.

[6] Todd Harrison et al., *Escalation & Deterrence in the Second Space Age*, Center for Strategic and International Studies (CSIS) Aerospace Security Project (Lanham, MD: Rowman & Littlefield Publishing, October 2017), 31.

[7] See Vincent Manzo, "Deterrence and Escalation in Cross-Domain Operations: Where Do Space and Cyberspace Fit?," *INSS Strategic Forum* 272 (December 2011).

whenever they select a target because it will "send a message." Acknowledging this and incorporating it into strategic thinking can help strategists develop creative solutions for deterrence. New symbolic associations can be identified or even constructed or changed intentionally. This article shows how using such a framework can generate solutions for space security.

Symbolism and Retaliation

Governments frequently communicate with actions rather than words. President Joseph Biden did not need to travel to Ukraine in February 2023 to talk with President Volodymyr Zelensky, but his visit to an active war zone symbolized America's support.[8] Without the need to explain its meaning, his presence in Ukraine conveyed a message. Military action can also be used to communicate symbolic messages. The United States has repeatedly flown nuclear-capable bombers on patrols in response to North Korean nuclear and missile tests.[9] These flights rarely demonstrate capabilities that are not already known, nor do they incur high costs or carry a serious risk of war. They simply resemble actions that could be taken in war and are best understood as symbolic responses to nuclear threats.

Indeed, it is common practice to base military strategy and national security policy on something as ambiguous as symbolism. Military planners might calculate their operations with precision to achieve specific military objectives, but national leaders make decisions based on much more intuitive considerations.[10] They want their military action to send a message to the enemy, knowing that verbal explanation may not be possible and that the action will speak for itself regardless of what is said.

What makes an action symbolic? A symbol typically refers to an object or action that represents some other object, action, or abstract idea, or some class of these things. By communicating through symbolism, the sender can embed a message in their action, enabling the receiver to make a mental association between the action and what it represents. This mental association could be based on any number of sources—appearance, functionality, precedent, or some other abstraction or flight of imagination. What matters is that the association between the action and meaning is perceived by the receiver and understood as a message from the sender.

Symbolism has typically been an important element of retaliation. One reason is that the purpose of the military action has to be communicated. States want their adversaries to know that the action is meant as punishment for a specific provocation. They also want adversaries to know that the action is limited, and that it is conditional on the adversary's behavior—it will stop if the provocations also stop. Sending that message is necessary to deter future transgressions without escalating into a broader

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[8] Peter Baker and Michael D. Shear, "Long Risky Night for Biden on Way to a Besieged Kyiv," *New York Times*, February 21, 2023, A1.

[9] For example, see Choe Sang-Hun, "In Show of Alliance, American Forces Fly B-52 Bomber over South Korea," *New York Times*, January 11, 2016, A4.

[10] Barry O'Neill, *Honor, Symbols and War* (Ann Arbor: University of Michigan Press, 1999).

conflict. If an adversary instead views the military action as unrelated, gratuitous, or opportunistic, it may not deter future provocations, and the opponent may feel compelled to counter-retaliate or take further military actions in self-defense.

Methods of Retaliation

There are many ways a military action in response to a provocation can symbolically communicate a state's intent. In addition to a response in kind, the target, the timing, the weapon used, the duration and intensity of attack, or the location can all send the desired message. In these ways, the military action may call to mind the act it is punishing and easily be recognized as retaliatory.

The most obvious way to send the message is for the response to be, in as many ways as possible, identical to the initial provocation. After North Korea launched eight missiles into the ocean east of the Korean peninsula last year, South Korea and the United States responded by launching the same number into the same waters. South Korea also conducted a "tit-for-tat" response to North Korea flying drones over the border between the two countries with cross-border drone flights of its own.[11] The resemblance between violation and response made clear that the response was chosen to punish the initial violation, and that it was intentionally chosen rather than coincidence.

If an identical response is not available, the choice of target can determine the message. In August 1964, the United States responded to reported attacks by North Vietnamese torpedo boats in the Gulf of Tonkin against two US Seventh Fleet destroyers with airstrikes against North Vietnamese naval vessels and facilities along the coast, though it must be noted that the second alleged attack against the destroyers almost certainly did not occur.[12]

There were other targets that could have imposed the same punishment, but they would not have communicated the same purpose. Though the method of strike differed, the target was sufficiently related to the original attacks to make its purpose clear. Later revelations suggest that President Lyndon B. Johnson was less interested in sending a message to North Vietnam than in putting on a performance for his domestic audience, but the response still contained the elements that created the appearance of a typical retaliation. Notably, the response was disproportionate in several ways—such as the number of casualties and targets destroyed.[13] Its appropriateness appeared to come from the relationship between the original attack and the targets struck.

Targets are frequently related to the provocation, as in the US airstrikes on terrorist training camps in Libya in 1986 after a Libya-sponsored terrorist attack in West Berlin, or US airstrikes against Iraq's nuclear facilities in 1993 after weapons inspectors

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[11] William Gallo, "South Korea Embraces 'Tit-for-Tat' Approach to North's Provocations," Voice of America, January 6, 2023, https://www.voanews.com/.

[12] See Edwin E. Moise, *Tonkin Gulf and the Escalation of the Vietnam War* (Chapel Hill: University of North Carolina Press, 1996).

[13] Moise, 221.

were denied access.[14] The airstrikes targeted the Iraqi Intelligence Directorate because that particular agency was responsible for the initial provocation. Other features of a retaliation such as the choice of weapon or its location can also send the appropriate message. It is even possible to send a message of retaliation if none of these are related to the attack. In Operation Desert Strike, the United States responded to a 1996 Iraqi attack against Kurdish forces with air strikes in another part of the country. The Kurdish areas were physically inaccessible because Allies refused to allow the United States to use their military bases, so attacks were concentrated against air defenses in the south.

US Army Major General Kurt Anderson, the commander of the operation, emphasized that a timely response was the most important part of that operation, presumably because it highlighted the connection between act and response: "Weapons effects were less important than the political goal of responding in a timely fashion."[15] As the previous examples also show, timing is usually an important part of retaliation. It surely helped that the United States had already established a pattern of using limited air strikes as punishment. It is also worth noting that the French government objected to the attacks because the targets were unrelated to the provocation, suggesting that the United States was pushing the limits of what was considered appropriate.[16]

There are, of course, many other considerations when designing a retaliation, and symbolism is not the only reason a response may resemble the initial provocation or include striking targets associated with it. Self-defense often requires military action against the source of the provocation. Military advisers may recommend responses within their areas of responsibility. Proportionality is easiest to achieve when the response is identical. Nevertheless, as the above examples show, symbolism often guides decision-making even when these are not considerations.

Responses to Space Aggression

China's and Russia's efforts to develop antisatellite weapons (ASATs) have alarmed American officials and forced them to think about how to respond to ASAT attacks.[17] Options for defending space systems can include maneuvering or hardening satellites, intercepting or destroying physical threats, or relying on redundancy and reconstitution to ensure continued operations.[18] Yet defending satellites is difficult. Satellites are fragile, visible, predictable, and limited in power and fuel. There are many potential

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[14] Judy G. Endicott, "Raid on Libya: Operation Eldorado Canyon," in *Short of War: Major USAF Contingency Operations* 1947–1997, ed. A. Timothy Warnock (Maxwell AFB, AL: Air University Press, 2000), 149; and Knights, *Cradle of Conflict*, 138, 143.

[15] Knights, 163.

[16] Frederic Bozo, *A History of the Iraq Crisis: France, the United States, and Iraq, 1991–2003* (New York: Columbia University Press, 2006), 42.

[17] Department of Defense (DoD), *Defense Space Strategy Summary* (Washington, DC: DoD, June 2020), 1–3.

[18] Todd Harrison, Kaitlyn Johnson, and Makena Young, *Defense against the Dark Arts in Space*, CSIS (Lanham, MD: Rowman & Littlefield Publishing, February 2021).

ways to disrupt their operations or their links to the ground, including missiles and other projectiles, lasers and microwaves, cyberattacks, signal jamming, and even grappling or ramming by other satellites.[19]

The vulnerability of satellites is why some have turned to the threat of retaliation to deter attacks. Retaliation could be nonmilitary and could include economic sanctions or the revocation of diplomatic privileges. Retaliation could also come in the form of military attacks meant to disrupt or destroy enemy targets. Perhaps the most important part of such a strategy is deciding what the response would be, or at least what response should be threatened. While the obvious response is retaliation in space, the general consensus among space experts is that this may be both ineffective and needlessly destructive.[20]

The United States, more than any other country, relies on satellites, so enemies may be willing to sacrifice their satellites to degrade or destroy American systems.[21] Further, retaliation in space could add to the debris problem and could be escalatory if an adversary does not have the capabilities to distinguish between a limited and an unlimited attack. It may also normalizie attacks in space.

Studies of space deterrence usually conclude the solution is a terrestrial or "cross-domain" retaliation.[22] Yet this solution usually lacks specifics on the methods and nature of a response. A recent RAND report typifies this issue: it advocates for "establishing the credibility of [cross-domain] threats" but provides no instruction how to do so.[23] Even the vague wording of official US policy to respond "at a time, place, manner, and domain of our choosing" suggests the government may not have decided what a response would be.[24] Of course many studies recognize terrestrial responses also face significant challenges.[25] They may be perceived as disproportionate and escalatory, particularly if they cause casualties.

Apart from a few exceptions discussed later, the only specific suggestion in the literature is that terrestrial targets should be space-supporting or space-related ground

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[19] National Air and Space Intelligence Center (NASIC), *Competing in Space* (Wright Patterson AFB, OH: NASIC Public Affairs, December 2018).

[20] Harrison et al., *Escalation*.

[21] Forrest E. Morgan, *Deterrence and First-Strike Stability in Space* (Santa Monica, CA: RAND Corporation, 2010), 26–27.

[22] Harrison et al., *Escalation*.

[23] Krista Langeland and Derek Grossman, *Tailoring Deterrence for China in Space* (Santa Monica, CA: RAND Corporation, 2021), 16.

[24] Donald J. Trump, *National Security Strategy of the United States of America* (Washington, DC: White House, December 2017), 31, https://trumpwhitehouse.archives.gov/; and Donald J. Trump, *National Space Policy of the United States of America* (Washington, DC: White House, December 9, 2020), 4, https://trumpwhitehouse.archives.gov/.

[25] Manzo, "Deterrence"; and Forrest Morgan, "Deterring Chinese Attacks," in *Cross-Domain Deterrence in US-China Strategy,* ed. James Scouras, Edward Smyth, and Thomas Mahnken (Laurel, MD: Johns Hopkins Applied Physics Lab, 2014), 41, https://apps.dtic.mil/.

stations or terminals.[26] There are military reasons why these targets might be selected to defend American satellites or disable those of the enemy.

Yet there is also clearly a symbolic reason why these kinds of targets could be selected. If the target for retaliation is space-related, the adversary would hopefully understand the attack as a response to a space-based provocation, which would make escalation less likely. While scholars do not explain target selection in these terms, they seem to recognize space-related retaliations are more appropriate and nonescalatory than nonspace-related ones. Without explicitly identifying the issue of symbolism, they are being constrained by it.

The problem is that for deterrence purposes, destroying ground stations or terminals suffers from the same challenge as retaliating in space: threatening to destroy space-related targets may not deter attacks if the enemy does not attach enough value to its space systems. While terrestrial attacks do not create space debris—except insofar as a satellite that the enemy has lost control of is debris—they do involve striking sovereign territory or causing casualties. Striking territory or causing casualties would likely be taken as crossing an important threshold and escalating the conflict. Nonlethal sabotage with cyberattacks or special operations could solve that problem but may be unavailable or not timely enough to send the right message.

Despite these shortcomings, the intuition to look to space-supporting ground stations is understandable. In fact, this is probably the best terrestrial response right now, as it is the most obvious solution. Enemies will perceive those targets were intentionally chosen as a direct response to the provocation.

This article identifies only two other possibilities in the literature: Vincent Manzo's thought experiment about striking air defenses, and King Mallory's suggestion for striking nonspace intelligence, surveillance, and reconnaissance, and command, control, and communications. Their justifications for these targets are addressed later, but the very fact these researchers have to provide detailed explanations why these targets are appropriate suggests that they are not obvious or intuitive choices and may not be understood by an enemy. Manzo acknowledges the dilemma, and in fact uses his example to illuminate it.[27]

Symbolic communication is often a search for the simple and intuitive, upon which shared meanings can be easily established. Space-related responses to space attacks make sense symbolically and are probably the least escalatory response; however, they are problematic for other reasons. The question, then, is what symbolically appropriate response would also achieve the goal of deterrence?

Why Words Are Not Enough

One might think presidential explanation could successfully convey the retaliatory purpose of an attack. The United States could strike an opponent's naval base and ex-

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[26] Harrison et al., *Escalation*, 31, 43–44; Morgan, 41; and Jim Cooper, "Updating Space Doctrine: How to Avoid World War III," War on the Rocks, July 23, 2021, https://warontherocks.com/.

[27] Manzo, "Deterrence," 4–5; and King Mallory, *New Challenges in Cross-Domain Deterrence* (Santa Monica, CA: RAND Corporation, 2018), 10–11.

plain that it was a retaliation for an attack in space. The government could try to avoid escalation by including a message outright, as Johnson did in announcing "We still seek no wider war" following the US retaliation to the Gulf of Tonkin incident. Yet it is worth remembering that the American reprisal in that operation was not just against any target—it was against "gunboats and certain supporting facilities . . . which have been used in these hostile operations."[28]

The action itself has to carry the intended message. That is because the action will carry some message no matter what is said. An example of this phenomenon comes from space itself. In February 2008, just over a year after China tested an ASAT on one of its defunct satellites, the United States similarly shot down one of its own satellites. The American government claimed that Operation Burnt Frost was not a response to China's test but was a safety measure against an out-of-control satellite.[29]

Yet this explanation drew a great deal of skepticism from Russia, China, and space security experts who interpreted it as a response to China's ASAT test.[30] Regardless of the official explanation, the nature and timing of the military operation sent a different message. The action spoke louder than the words.

Operation Burnt Frost shows that the symbolic content of the action will outweigh a verbal explanation. The United States may have been counting on it to send a message to China. In this case, the appearance of retaliation eclipsed the claims that the operation was unrelated. Conversely, the appearance that cross-domain attacks are unrelated may outweigh verbal claims that they are retaliatory. That is why a terrestrial response to space aggression requires some symbolic relation to the aggression itself.

A retaliatory strike against, say, a naval base or a railroad bridge in response to a satellite attack would not be viewed as an appropriate or even explicable reaction. Instead, it would likely be viewed as opportunistic, meant to prepare for further military action, achieve some other unrelated tactical objective, or gratuitously harm the opponent. Any attempt to explain it would seem post hoc and would be dismissed as disingenuous.

Explaining a retaliation after the fact is insufficient. Instead, the response has to carry a message of retaliation without the need for explanation. It has to be obvious that it was chosen to convey the message. That is why many authors default to space-based or space-related targets. Yet, since space-based or space-related targets are insufficient, the default choice does not work. The only option left is to imbue some other target with the same symbolic meaning. Once that is done, explanations will not be necessary.

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[28] Ezra Y. Siff, *Why the Senate Slept: The Gulf of Tonkin Resolution and the Beginning of America's Vietnam War* (Westport, CT: Praeger Publishers, 1999), 113–14.

[29] Nicholas L. Johnson, "Operation Burnt Frost: A View from the Inside," *Space Policy* 56 (May 2021); and James Oberg, "Assessing the Hazards of Space Hydrazine, and the Media Reportage of It," Space Review, August 25, 2008, https://www.thespacereview.com/.

[30] Noah Shachtman, "Experts Scoff at Sat Shoot-Down Rationale," Wired, February 15, 2008, https://www.wired.com/; and Alexis A. Blanc et al., *Chinese and Russian Perceptions of and Responses to U.S. Military Activities in the Space Domain* (Santa Monica, CA: RAND Corporation, 2022), 30–31, https://doi.org/.

As noted earlier, attacking a space-supporting ground station can send the right message even though the target is not in space. This suggests that convincing the adversary some other terrestrial target is space- or satellite-related—or part of some category of objects that includes satellites—could make it possible to send the same message. Different from simply communicating the relationship verbally, this requires creating the mental association in the mind of the adversary so that the action makes sense without an accompanying verbal explanation.

Symbolism and Shared Perception

Symbolism relies on shared perception. Symbolism is about the associations made collectively as a society, not just the associations an individual makes in their own mind. The need for shared perception is why symbolic objects are often similar in appearance to the thing they represent. It is also why symbolic actions frequently mimic widespread cultural practices, as when two national leaders shake hands to represent friendship between their countries. All actors are aware of the relationship between the symbol and what it represents. It is only through this shared perception—not just the knowledge of an association, but the knowledge that others make the association, that others know you make the association, and so on—that the message is understood to be intentional.

This is why diplomacy often invokes explanations that "the United States would view" an action in some manner, or that "the United States makes no distinction" between different aggressive acts. In the Cuban Missile Crisis, for instance, the Kennedy administration declared that it would consider any attack "against any nation in the Western Hemisphere as an attack by the Soviet Union on the United States."[31] The government did not simply make a threat, but communicated how it perceived or categorized certain actions.[32] The goal is for the adversary to understand this perception—the meaning an attack would convey—and for the United States to know that it understands it.

Shared perceptions can be shaped through explanation. But a single declaration may not be enough to create that new shared perception. New perceptions have to be socialized, an issue addressed later in the article. Moreover, not just any explanation will do. If explanations are unreasonable or appear ad hoc, one side will not accept that the other perceives or categorizes an action in the way they claim, and a shared perception will not be formed.

The Cuban Missile Crisis example suggests the starting point for credible cross-domain deterrence should be identifying options for the United States to declare it "makes no distinction" or sees a relationship between a space-based and terrestrial attack. Then it can adopt strategies for creating that new perception. The goal is to

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[31] James Hershberg, "The Cuban Missile Crisis," in *The Cambridge History of the Cold War*, ed. Melvyn P. Leffer and Odd Arne Westad (Cambridge, UK: Cambridge University Press, 2010), 75.

[32] Asma Khalid, "How Biden Is Trying to Clean Up His Comments about Russia and Ukraine," NPR, January 20, 2022, https://www.npr.org/.

identify a simple and intuitive category that could include space systems and other terrestrial targets, one that would form the basis of reasonable shared understanding. If it is too complicated or far-fetched, it will be dismissed as opportunistic. It would have to be defensible and justifiable, even compelling. It would be most effective if it were based on principles that were already widely accepted, which would lower the barrier to shared understanding and acceptance.

If space-supporting ground sites are seen as appropriate targets, even though these targets are technically cross-domain, other cross-domain attacks might be acceptable if the targets are functionally related to space. If the United States could successfully argue it makes no distinction between satellites and some other type of asset based on their function, then perhaps it could recategorize that asset as a legitimate target for retaliation.

For example, debate is underway whether the US government should designate space systems as critical national infrastructure, alongside nuclear reactors, the electrical grid, and other key civilian assets.[33] Indeed, space assets have become essential parts of the national economy, something US Space Force and US Space Command leaders have repeatedly emphasized. This redesignation could create a recognized association between satellites and other civilian infrastructure, such that retaliation against other kinds of infrastructure would make sense. If satellites are widely viewed as civilian or homeland targets, then civilian or homeland responses might seem appropriate.

Yet attacking civilian infrastructure is generally frowned upon—and for good reason—and it violates international law. Such an obscure redesignation by the government would not convince many people anyway without a concerted effort to publicize the new categorization.

Mallory and Manzo have both made suggestions based on military function. Mallory suggests directly targeting terrestrial communication and intelligence, surveillance, and reconnaissance (ISR), since these are satellite functions. Manzo suggests targeting air defenses because air-based ISR would have to replace space-based ISR, though he acknowledges that the logic may not be understood by an adversary. These attacks may be understood by some in the military, but they may be too obscure for a wider audience. They could, however, be a starting place if the United States were to intentionally educate the world on these categories.

Failing that, the United States could invent new categories. The term weapons of mass destruction, for example, has created a widely recognized association between nuclear, chemical, and biological weapons despite the differences in their physical attributes, military uses, and potential for so-called mass destruction. This term enabled the Bush administration to conflate the threats from Iraq's chemical and nuclear weapons programs when justifying the Iraq War. The association may have also made possible the Ameri-

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[33] Frank J. Cilluffo and Mark Montgomery, "Time to Designate Space Systems as Critical Infrastructure," *SpaceNews*, April 14, 2023.

can threat of "the strongest possible response"—widely viewed as a reference to nuclear weapons —if Iraq used chemical or biological weapons in the Gulf War.[34]

Perhaps the United States could begin to socialize new terms such as "critical military infrastructure" or "war-supporting digital systems" when describing satellites. These phrases can encompass the military functions Mallory and Manzo discuss that are shared between satellites and terrestrial targets. Adversaries may then understand retaliation against those other military targets as logical responses to space aggression. This would have the added benefit of not crossing the threshold to civilian targets. Responses would also be more justifiable in international law if they served a self-defense purpose.

Another possibility suggested by the example of US airstrikes on the Iraqi Intelligence Directorate is to target assets controlled by the government agency or private entity that operates the satellite. That could be particularly effective if that entity has assets other than space systems. Surely, as the space domain develops and its contours become more well-known in the public consciousness, other possibilities not identified here will present themselves.

Constructing Symbols in International Relations

Creating new symbolic meanings is difficult, and there is no guarantee that the approach suggested here would work. Introducing a new association, or changing the meaning of an object or action, requires establishing a new collective understanding. It is almost like redefining the meaning of a word. As discussed above, all relevant actors must understand the new definition—and recognize that others do, too—for it to be used for communicative purposes. Relevant actors may even have an incentive to pretend not to understand or to offer a competing conception if they do not want to accept a redefined category or symbolic understanding.

Precedent

If the United States decides to redefine or recategorize satellites or space systems, how can it ensure the definition becomes universal? Establishing precedent over time is one method. For example, through repeated use, the United States has made it clear it views sanctions and airstrikes as its default methods for punishment against a range of transgressions.[35] Adversaries and observers can understand the United States' intent when these tools are used.

Though the targets usually have a relationship to the transgression, the United States could try to establish a default set of targets that it attacks after space aggression, or any provocation for that matter. In that way, an adversary would understand the

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[34] Micah Sifry and Christopher Cerf, *The Gulf War Reader: History, Documents, Opinions* (New York: Random House, 1991), 178–79.

[35] Daniel Byman and Matthew Waxman, *The Dynamics of Coercion: American Foreign Policy and the Limits of Military Might* (Cambridge, UK: Cambridge University Press, 2002), 88, 107.

retaliation and the message it sends, even if the target is not directly related to an attack against satellites.

Negotiated Agreement

Negotiated agreements are another way. States can codify shared definitions and principles. Perhaps satellites could be legally categorized as a specific type of protected asset along with other similar assets. Lawyers frequently create new categories or distinguish between different types of assets to apply different legal standards. Reprisal is not usually allowed by international law, but recategorizing satellites could also redefine what kind of responses are recognized as tit-for-tat or in-kind.

Yet neither of these avenues—precedent or negotiated agreements—are very realistic. The former would be escalatory and the latter would be a nonstarter.

Information Campaign

Instead, redefinition requires something like an information campaign—an intentional, long-term, public effort to convince other countries that the United States views space aggression as falling into a certain category of attack. It would not be the usual information campaign. The goal of the campaign would not simply be to convey a message but to shape shared perceptions and collective understandings about the nature of satellites. The campaign would also require more than just messages; it would include more extensive efforts at socializing new definitions. Those efforts themselves may be symbolic or ritualistic.

Repeated declarations would, of course, be part of this process. Domestic legal redefinitions could also be involved, as well as proposals at the United Nations or within treaties, though these would be insufficient on their own. Various diplomatic rituals as well as military exercises could be used to make the recategorization official. Many diplomatic activities are meant to change public perceptions, including, for example, holding defense agreement-signing ceremonies to convince observers that aggression against one is aggression against all. Such rituals could be developed for space.

Meanings are not infinitely malleable and there is no guarantee that new categories will take hold. Space is physically, scientifically, legally, and semantically distinct from other domains, and that distinction has been constructed since before the start of the Space Age. An opponent would have every incentive to reject American attempts to reframe satellites as being part of some terrestrial infrastructure. They would almost certainly dismiss any attempt at such a redefinition as opportunistic, illogical, or dangerous. The distinction between space and Earth may have even served us well: The notion of space as a sanctuary from military conflict may have helped keep the domain peaceful all these years.

Moreover, certain thresholds will likely retain their resonance regardless of efforts to remove them or define new associations that cross them. Probably the most important threshold—and the main distinction between space attack and terrestrial attack—are fatalities. Attacks against satellites do not directly kill people, whereas terrestrial attacks often do. It will be very difficult to convince people that crossing the line into lethal force is justified by an attack on an unmanned vehicle in space. Military space professionals are fond of reminding audiences that "satellites don't have mothers."[36] The problem of lethal force has led space strategists to focus on unmanned targets and nonlethal means such as cyberattacks and sanctions. Cyberattacks may have an added symbolic advantage in that, like attacks in space, they are new, secretive, and high-tech, so they could be associated with space in people's minds.

It will be nearly impossible to minimize or eliminate the delineation between lethal and nonlethal attacks—nor is it a good idea to try, as the distinction serves humanity well. It is such an important, natural, and long-standing distinction that crossing it will surely be seen as escalatory. Perhaps redefining satellites as critical civilian infrastructure or critical military infrastructure could convince observers that attacks in space also put lives at risk, but that may be too sophisticated an argument to have wide appeal. Sanctions are still often viewed as nonlethal policy responses despite their potential to create fatalities. Ultimately, terrestrial responses to space aggression may have to remain nonlethal.

Another major distinction is one of territory. An attack in space is against a vehicle controlled by a sovereign state, but states cannot claim sovereignty over any part of space. Retaliation against a state's sovereign territory would likely be seen as crossing an important and escalatory threshold. Yet this is probably more permeable than the lethality threshold. States frequently take aggressive actions against each other's territory. Just as the United States attacked naval targets in North Vietnam in response to an attack on its naval vessels in international waters, it may be able to attack relevant targets on another's territory in responses to an apparent attack.

Conclusion

Some may believe that a search for terrestrial responses is unnecessary. Perhaps international condemnation, economic sanctions, or retaliation in space would be enough to deter military aggression in space. Conversely, space aggression might end up being covert enough that retaliation is unnecessary. There are clearly those who believe that deterring aggression in space is inseparable from the problem of deterring war on Earth, making specific responses to space aggression irrelevant.

While there is some validity to these views, the United States does need to be prepared to retaliate to limited military actions in space. Attacks are possible in both crises and limited wars. Russia's war in Ukraine, for instance, does not involve direct conflict between the United States and Russia, but there may exist a temptation to attempt to disable the other's space systems. Even direct conflicts between major powers are likely to have limits. During the Korean War, the United States did not use nuclear weapons, strike Chinese territory, or launch attacks at sea. These limits were, to some

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[36] General John E. Hyten, "Mitchell Institute Breakfast Series," speech, June 20, 2017, US Strategic Command (website), https://www.stratcom.mil/.

degree, sustained by the fear of reciprocal attack. In a direct conflict between powerful states, the fear of retaliation may lead them to respect limits against space attacks.

For now, the reframing of military actions in space is moving less toward legitimizing cross-domain responses and more toward making finer distinctions about what is and is not allowed in space itself. The United States has attempted to establish norms against acts that create debris and dangerous rendezvous and proximity operations.[37] Still, this also does not invalidate the search for terrestrial responses in support of deterrence. Perhaps terrestrial responses would only be reasonable following certain types of attacks in space, such as those that cause debris. The new distinctions make the deterrence problem more complicated, but not impossible. They simply demand more creative solutions to identifying or imagining cross-domain retaliations. Æ

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[37] Sandra Erwin, "DOD Updates Space Policy, Formally Adopts 'Tenets of Responsible Behavior,' " *SpaceNews*, September 6, 2022.

US SPACE COMMAND'S DETERRENT ROLE

Alex Turpin

Growing global interest in developing space-based systems, from economic to defense, make the requirements of the Outer Space Treaty of 1967 to maintain a peaceful space environment even more challenging. As US Space Command works to deter aggression in space, an examination of deterrence theory and the US and Soviet experience before, during, and after the 1983 Able Archer exercise provides insights for a successful approach to deterrence in space. Such an approach should be focused on stratified deterrence, dissuasion deterrence, and control of space.

Over the years, deterrence theory has gone through several permutations.[1] Still, at its core, it generally relies on using military and nonmilitary threats to prevent an aggressor from acting.[2] The impetus to deter aggression in space grows stronger every year. But what does deterrence look like in space?

Analysis of contemporary deterrence theories and their real-world applications provide a foundation for US Space Command to understand how current geopolitical conditions influence deterrence efforts in the space domain. Such an analysis demonstrates deterrence is a multifaceted and complex endeavor. At its core, deterrence is achieved through low-level diplomatic efforts of the command, which must engage with all of the actors in space.

The command must develop relevant deterrence strategies that address the unique context and perspective of each actor, develop resilient space network solutions, and seize leadership control of space to maintain globally responsible space behavior. A review of the evolution of thinking regarding the United States' approach to space deterrence and an analysis of nuclear war theory as well as the historical case study Able Archer 83 reveal the ways in which US Space Command can successfully deter aggression in space in a multipolar world.

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[1] Frans-Paul van der Putten, Minke Meijnders, and Jan Rood, "Deterrence as a Security Concept against Non-Traditional Threats," in *Clingendael Monitor 2015*, ed. Frans-Paul van der Putten, Minke Meijnders, and Jan Rood (Hague, Netherlands: Clingendael Institute, June 2015), 9, https://www.clingendael.org/.

[2] Michael Mazarr, *Understanding Deterrence* (Santa Monica, CA: RAND Corporation, 2018), 4.

Background

In 1961 the United Nations General Assembly passed Resolution 1721, declaring space was free and open to all nations.[3] Essentially, war was off-limits in space. This did not prevent various countries from attempting to leverage space to support military actions in other domains and hence the United States from considering countermeasures. In 1962, President John F. Kennedy debated whether using reconnaissance satellites was peaceful or aggressive.[4] In 1983, President Ronald Reagan introduced the Strategic Defense Initiative, seeking to use space-based assets to detect Soviet missile launches.[5] This was followed by the first Gulf War in 1991, which featured the integration of space to facilitate terrestrial warfare.[6] Today, commercial space assets have been used heavily in Ukraine for communications, targeting, and reconnaissance.[7] Space has now become an integral part of most advanced nations' strategic thinking, encompassing all elements of national power.

As technology evolves and space becomes more accessible, US Space Command faces the dilemma of deterring aggression in space from global competitors while adhering to the international ideals of the Outer Space Treaty of 1967, which ensures that "the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind."[8] China, for one, is building its space capabilities with an eye toward "expansionism, territoriality, and resource nationalism."[9] The United States is primarily interested in commercial and military uses of space, and it has stated that extraterrestrial resource extraction is vital to further space exploration deeper in the solar system.[10]

As the ability to harvest valuable resources from space becomes a reality, so will the potential for conflict, both terrestrially and in space. Many countries are taking an interest in space-resource harvesting. Absent a coherent global legal framework that

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[3] UN General Assembly, Resolution 1721 (XVI), International Co-operation in the Peaceful Uses of Outer Space, December 20, 1961, https://www.unoosa.org/.

[4] National Security Council Meetings, 1962: No. 502, July 10, 1962, Papers of John F. Kennedy (JFK), Series 06: Meetings and Memoranda, JFK Presidential Library and Museum, Boston, MA, 5, https://www.jfklibrary.org/.

[5] Ronald Reagan, "Address to the Nation on Defense and National Security," March 23, 1983, transcript, Ronald Reagan Presidential Library and Museum, https://www.reaganlibrary.gov/.

[6] Cassandra Steer, "Global Commons, Cosmic Commons: Implications of Military and Security Uses of Outer Space," *Georgetown Journal of International Affairs* 18, no. 1 (Winter/Spring 2017): 11.

[7] Gregory C. Allen, "Across Drones, AI, and Space, Commercial Tech Is Flexing Military Muscle in Ukraine," Center for Strategic and International Studies (CSIS), May 13, 2022, https://www.csis.org.

[8] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty), December 19, 1966, UN Res 2222 (XXI), https://digitallibrary.un.org/.

[9] Namrata Goswami, "China in Space: Ambitions and Possible Conflict," *Strategic Studies Quarterly* 12, no. 1 (Spring 2018): 75.

[10] "2021 COPUOS Legal Subcommittee – U.S. on the Exploration, Exploitation, and Utilization of Space Resources," US Mission to International Organizations in Vienna, June 1, 2021, https://vienna.usmission.gov/.

establishes a rules-based approach to this problem, the potential for aggression remains an issue.[11]

Terms

Joint publication 3-0, *Joint Campaigns and Operations,* defines deterrence as "the prevention of action by the existence of a credible threat of unacceptable counteraction and/or belief that the cost of action outweighs the perceived benefits."[12] In the space domain, deterrence serves to prevent conflict and with defense secures free access, defined as the "freedom to operate in space."[13] The Outer Space Treaty of 1967 describes free access as "exploration . . . without discrimination of any kind, on a basis of equality and in accordance with international law."[14] Free access is the ability of any state to explore and operate in space as it sees fit while remaining within the constraints of international law.

The Evolution of Deterrence

In the 1950s, the development of nuclear weapons caused the concept of deterrence to evolve.[15] Military strategist Bernard Brodie wrestled with the idea that new weapons delivery methods made defense almost impossible, noting the possibility of nuclear war becoming a total war of unlimited destruction due to inflamed passions.[16] This led him to consider limited or peripheral wars managed by politics, designed to advance US interests while avoiding the threat of total nuclear war.

Brodie's theory centered on the idea of rationality: clearheaded state leaders acting rationally in response to outside stimuli. In other words, one could almost predict that a particular action, such as threatening a nuclear launch, would result in a desirable reaction, such as political concessions or the standing down of military forces. This idea of rationality is evident in how Kennedy managed the Cold War. His concepts of "mutual destruction" and "assured destruction" attempted to appeal to a rational, calculating opponent by positing both sides would be destroyed in a nuclear exchange,

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[11] Ian Christensen et al., "New Policies Needed to Advance Space Mining," *Issues in Science and Technology* 35, No. 2 (Winter 2019): 30.

[12] Chairman of the Joint Chiefs of Staff (CJCS), *Joint Campaigns and Operations*, Joint Publication 3-0 (Washington, DC: CJCS, 2022), GL-9.

[13] US Space Command (USSPACECOM), *Never a Day without Space* (USSPACECOM Annual Report) (Washington, DC: USSPACECOM, 2021), 9, https://media.defense.gov/.

[14] Outer Space Treaty.

[15] Robert P. Haffa Jr., "The Future of Conventional Deterrence: Strategies for Great Power Competition," *Strategic Studies Quarterly* 12, no. 4 (Winter 2018): 96, https://www.airuniversity.af.edu/Portals/.

[16] Bernard Brodie, *Some Strategic Implications of the Nuclear Revolution* (Salt Lake City: Institute of International Studies at the University of Utah, 1959), 7, 10–11.

meaning that neither side would win.[17] In theory, this realization would deter both opponents from starting a nuclear exchange.

In a 1960 speech, then-Senator Kennedy referenced nuclear mutual destruction during his campaign to disarm nuclear states and prevent total war.[18] Realizing that this goal was unattainable, Kennedy shifted to a policy of assured destruction, elaborated by Secretary of Defense Robert S. McNamara to mean "the United States would be able to destroy in retaliation 20 to 25 percent of the Soviet Union's population and 50 percent of its industrial capacity."[19] In essence, Kennedy saw deterrence as defensive, with diplomacy in the lead, working to prevent a nuclear exchange through active perception management.

In the years following the Cuban Missile Crisis, Brodie realized rationality in turn depends on context and perspective. He noted nuclear deterrence in particular is based on "human behavior under great emotional stress in circumstances that have never been experienced."[20]

Space war is still theoretical, as technology is still some years away from making it a reality. Yet context and perspective—understanding what drives the opponent, including domestic and international concerns, historical tensions, and emotional factors—are still relevant to deterring war in space.

Deterrence in Space

Scholarly thought on deterrence in space emerged in the 1980s. Reacting to the 1979 Strategic Arms Limitation Talks II Treaty, Colin Gray advocated against arms control treaties that would limit US space weapons development.[21] Everett Dolman extended this thinking to argue for the United States to abandon the Outer Space Treaty and militarily seize control of low Earth orbit, using this to negotiate a new set of space rules.[22]

More recently, some scholars have argued war in space is a foregone conclusion and provided ideas on how to win, while others have extended Dolman's thinking to argue the United States must declassify its space capabilities in order to message a

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[17] John F. Kennedy, "Disarmament," April 22, 1960, draft and notes of speech, JFK Papers, Series 12: Speeches and the Press, Reading Copies, 1958–1960, JFK Presidential Library and Museum, 4, https://www.jfklibrary.org/.

[18] Kennedy; and "Robert S. McNamara," Historical Office, Office of the Secretary of Defense, n. d., accessed November 12, 2022, https://history.defense.gov/.

[19] "McNamara."

[20] Bernard Brodie, *Escalation and the Nuclear Option* (Santa Monica, CA: RAND Corporation, 1965), 11.

[21] Colin S. Gray, *American Military Space Policy: Information Systems, Weapon Systems and Arms Control* (Cambridge, MA: Abt Books, 1982), 54.

[22] Everett C. Dolman, "New Frontiers, Old Realities," *Strategic Studies Quarterly* 6, no. 1 (Spring 2012): 94, https://www.airuniversity.af.edu/Portals.

credible threat to potential enemies to deter space war.[23] Together, these ideas have sought to deter space war by using military strength and weaponry to enact strategies of denial and punishment.[24] Indeed, these ideas make room for peaceful coexistence in space; however, the common theme among such views is cooperation from a position of real strength.

Conversely, a growing chorus of authors approach deterrence from the perspective of diplomacy. A number of thinkers advocate for using diplomacy to prevent space conflict—a decidedly less-militaristic approach to the problem. Some who study the issue with regard to China's growing space capabilities argue the United States must first increase its space presence and technological capacity to provide a position of credibility for diplomatic efforts.[25] Others take a diplomacy-first approach, advocating for a perception-management-and-cooperation approach to deterrence.[26] These approaches recognize the need to understand US adversaries while using a carrot-and-stick strategy empathetically.

Some diplomacy-focused scholars argue enhancing the US position in space requires a greater emphasis on alliances and commercial integration to increase the resiliency of US space systems while isolating aggressive space competitors. Overall, the common theme among this group is that diplomacy, both political and military, is required. Adversaries can impose their meaning on events if the other side is silent. In effect, diplomacy can prevent potentially catastrophic misunderstandings while allowing all to benefit from space, keeping with the ideals of the Outer Space Treaty.

To provide a theoretical framework for US Space Command leaders to develop a comprehensive deterrence strategy for space, this article considers two related questions: 1) How can deterrence can be achieved in space? and 2) How can US Space Command develop this deterrent effect in a multipolar world? A study of Able Archer 83, the concluding exercise of a much longer NATO exercise designed to simulate a massive nuclear release against the Soviets, discussed in the context of Brodie's work and nuclear deterrence theory, will help answer these questions.[27] Able Archer 83 is crucial to an understanding of deterrence because it illustrates the action-reaction cycle in which opponents engage in increasingly aggressive behavior to maintain an

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[23] Paul S. Szymanski, "How to Win the Next Space War: An Assessment," Wild Blue Yonder, April 4, 2022, https://www.airuniversity.af.edu/; and Todd Harrison et al., *Escalation and Deterrence in the Second Space Age* (Washington, DC: CSIS, October 2017): 31, https://csis-website-prod.s3.amazonaws.com/.

[24] Mazarr, *Understanding Deterrence,* 2.

[25] Dean Cheng, "China's Military Role in Space," *Strategic Studies Quarterly* 6, no. 1 (Spring 2012): 74, https://www.airuniversity.af.edu/Portals/.

[26] Joan Johnson-Freese, "A Space Mission Force for the Global Commons of Space," *SAIS Review of International Affairs* 36, no. 2 (Summer–Fall 2016): 11–12; and Steer, "Global Commons," 13–14.

[27] Nathan Bennett Jones, *Able Archer 83: The Secret History of the NATO Exercise That Almost Triggered Nuclear War* (New York: New Press, 2016), 1.

edge.[28] The United States used threatening words and actions against the Soviets in an attempt to deter nuclear war. Instead, this approach nearly led to disaster.

Able Archer 83

The period under consideration for the Able Archer case study will be limited to 1980–83, coinciding with President Ronald Reagan's first term in office. Following a decade of détente, during which the United States negotiated with the USSR as equals, Reagan entered the White House determined to negotiate from a position of dominance to end the threat of communism.[29] Reagan had been a known entity to Soviet intelligence. In 1964, he delivered a speech to the Republican National Convention in which he remarked on the evils of socialism and decried those in America who would lead the nation "under the banners of Marx, Lenin, and Stalin."[30] His rhetoric had only grown more robust and divisive in the subsequent decade. When Reagan was elected president in 1980, US-Soviet tensions began to rise.

In 1981, the Soviets launched Operation RYaN [*Raketno Yadernoye Napadenie*, translated as nuclear missile attack], a "worldwide intelligence operation" that required all intelligence agents to watch for a series of indicators that the United States was preparing for a nuclear attack.[31] Fearing a US first strike, the Soviets wanted as much warning as possible to enable a counterstrike. The Soviets considered every piece of information, no matter how small, as vitally important.[32] Two years later, the annual NATO exercise in Europe, code-named Able Archer, would test the limits of the Soviet intelligence effort.

The two purposes of the annual Able Archer exercise were to test the NATO command-and-control structure and exercise the decision-making process as conventional war with the Soviet transition to nuclear war.[33] The 1983 exercise came at the end of a series of exercises conducted by NATO under the umbrella name Autumn Forge 83, which included the REFORGER exercise that rehearsed the movement of troops from the United States to Germany.

Although the United States and NATO considered Able Archer 83 to be a routine exercise, it included such elements as "radio silences, the loading of warheads, reports of 'nuclear strikes' on open radio frequencies, and a countdown through all DEFCON

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[28] George W. Rathjens, "The Dynamics of the Arms Race," *Scientific American* 220, no. 4 (April 1969): 19, https://www.scientificamerican.com/.

[29] Marc Ambinder, *The Brink: President Reagan and the Nuclear War Scare of 1983* (New York: Simon & Schuster, 2018), 24.

[30] Ronald Reagan, "A Time for Choosing," October 27, 1964, speech transcript, Reagan Presidential Library and Museum, https://www.reaganlibrary.gov.

[31] Ambinder, *Brink,* 60.

[32] Ambinder, 120.

[33] Jones, *Able Archer 83*, 25–26.

[defense-ready condition] phases to 'general alert.' "[34] Operation RYaN led the Soviets to conclude the United States was preparing for a nuclear first strike.[35]

Key events leading to Able Archer 83 that increased tensions began as early as 1981. To gain insight into Soviet intelligence and radar capabilities and cloud their view of US intentions, the US military conducted psychological operations using the Navy and the Air Force to penetrate Soviet-controlled areas. These incursions fed into Soviet paranoia because of fears that the United States was testing Soviet reaction times in preparation for a nuclear strike. Additionally, the US deployment of nuclear-capable Pershing II missiles in Europe increased Soviet fears of a US first strike due to the short flight time required to hit Russia.[36]

Such fears contributed to a Russian pilot's shootdown of Korean Air Lines Flight 007 on September 1, 1983.[37] The US reaction was swift and accusatory. In a radio address on September 2, Reagan characterized the Soviet action as an act of terrorism and stated, "What can be the scope of legitimate and mutual discourse with a state whose values permit such atrocities?"[38] Later, on September 5, Reagan gave another speech, calling the incident a "crime against humanity."[39] The November Able Archer 83 began against this backdrop of heightened tensions and loaded rhetoric. According to a report issued in 1990 by the president's Foreign Intelligence Advisory Board, the Soviet perception on the eve of the exercise was that "the international situation at present is white hot, thoroughly white hot."[40]

Conducted November 7–11, 1983, after the REFORGER exercise, Able Archer 83 was an "annual command post exercise to practice nuclear release procedures."[41] Two factors differentiated this exercise from those of previous years. The first was testing the communications architecture from the US European Command headquarters down to the firing units and rehearsing updated procedures "for releasing nuclear weaponry."[42] The second was a planned notional increase in the threat levels from "normal readiness, through the various alert phases, to a general alert."[43]

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34. Jones, 26.

35. Jones, 26.

36. President's Foreign Intelligence Advisory Board, "The Soviet 'War Scare,' " February 15, 1990, National Security Archive, 62, https://nsarchive.gwu.edu/.

37. Paul Dibb, *The Nuclear War Scare of 1983: How Serious Was It?* (Barton, Australia: Australian Strategic Policy Institute, October 10, 2013), 4, https://www.aspi.org.au/.

38. Ronald Reagan, "Remarks to Reporters on the Soviet Attack on a Korean Civilian Airliner," September 2, 1983, transcript, Reagan Presidential Library and Museum, https://www.reaganlibrary.gov.

39. Ronald Reagan, "Address to the Nation on the Soviet Attack on a Korean Civilian Airliner," September 5, 1983, transcript, Reagan Presidential Library and Museum, https://www.reaganlibrary.gov/.

40. Gregory Romanov (Politburo member), speech at the Kremlin, November 7, 1983, as qtd. in Advisory Board, "Soviet 'War Scare,' " 69.

41. Advisory Board, 69.

42. Advisory Board, 70.

43. Advisory Board, 70.

Whether the Soviets actually feared a US nuclear strike under cover of the Able Archer 83 exercise remains questionable.[44] One historian argues the Soviets understood the exercise as a routine test command post exercise; however, their greatest fear was a miscalculation, not an intentional decision, that would lead to nuclear war. As noted above, Reagan used inflammatory rhetoric throughout his presidency when describing the Soviet Union.[45] As the historian contends, "Reagan's words and deeds elevated fears of an accidental nuclear war in the Soviet Union."[46]

Diplomacy occurred during this tense period of the Cold War, but it was overshadowed by political rhetoric and undercut by the increased risk of tragic miscalculation. Although assessments differ about whether the United States and the Soviets were on the brink of nuclear war, there is ample evidence that the early 1980s featured much higher tensions than had occurred during the era of détente in the 1970s. The downing of Korean Air Lines Flight 007 is recognized as one of the more pivotal moments of such tensions felt during the early 1980s.[47]

An analysis of these elements from the case study and the theories of Brodie and others can guide US Space Command efforts toward deterring aggression in space.

Deterrence in Space: Challenges

Resiliency: Absorbing Punishment

How can deterrence be achieved in space? In 1946, Brodie observed, "No adequate defense against the bomb exists, and the possibilities of its existence in the future are exceedingly remote."[48] He determined one of the best historical defenses against missile weapons was the ability "to absorb punishment."[49] Yet with the advent of atomic weapons, the ability of targets to absorb missile attacks and continue fighting was gone. Similarly, geostationary and mid-Earth space assets have been large, delicate single sources of failure.[50] A single strike could destroy an enemy's capability until a new satellite could be launched. Brodie notes that strong defensive measures, openness to international security agreements, and alliances with non-nuclear states are the keys to preventing atomic war.[51]

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[44] Simon Miles, "The War Scare That Wasn't: Able Archer 83 and the Myths of the Second Cold War," *Journal of Cold War Studies* 22, no. 3 (Summer 2020): 86–89.

[45] Miles, 92.

[46] Miles, 111.

[47] Miles, 113.

[48] Bernard Brodie, "War in the Atomic Age," in *The Absolute Weapon: Atomic Power and World Order*, ed. Bernard Brodie (New Haven, CT: Yale Institute of International Studies, 1946), 28.

[49] Brodie, 29.

[50] Rachel Zisk, "The National Defense Space Architecture (NDSA): An Explainer," Space Development Agency, December 5, 2022. https://www.sda.mil/.

[51] Bernard Brodie, "Implications for Military Policy," in *The Absolute Weapon*, 62.

The development of renewable mesh networks such as Starlink and the National Defense Space Architecture (NDSA) has enabled resiliency in space-based communication, while technology has allowed for the rapid reconstitution of certain space assets. This resiliency renders the military element of surprise increasingly irrelevant, leading to a greater deterrent effect on potential enemies. The ability to absorb damage and with minimal loss of space-based functionality could lead an aggressor to decide not to attack because they would be unable to cause enough damage to make the effort worthwhile.[52]

Status Quo: Nuclear Weapons and Space Militarization

Given the high-stakes nature of the Cold War, one could reasonably assume any action involving nuclear weapons might trigger a more significant conflict. Although war never happened, there were several instances of brinkmanship, with each side pushing the envelope and attempting to gain positional or political advantage. Neither side wanted nuclear war—and indeed, neither did the world at large—however, both sides postured forces and weapons in provocative ways to see how much they could get away with before instigating a response.

In this Cold War status quo of sorts, the use of nuclear weapons was implicitly understood as undesirable by the superpowers. Accordingly, both sides exercised restraint during tense situations to avoid using these weapons, even as they pushed the line to just below the threshold of this nuclear status quo.

A 2023 analysis of the motivations and ambitions of the United States, Russia, and China in space reveals all sides tend to explicitly state their desire to avoid militarizing space.[53] Yet maintaining this status quo has not precluded all three states from declaring space as a warfighting domain, developing ground-based space weapons, and using space to support terrestrial warfighting.[54] Meanwhile, other spacefaring nations and private companies continue contributing to a complex and evolving space environment, making the original United Nations principle of free access to space increasingly challenging to uphold.

Attribution and Proportionality

In addition to the problem of the status quo in space, two other challenges face US Space Command in deterring aggression in space: attribution and proportionality of response.[55] Attribution is the ability to identify the perpetrator of an attack positively and quickly. Yet space is a vast area with numerous actors launching many satellites.

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[52] James Clay Moltz, "The Changing Dynamics of Twenty-First-Century Space Power," *Journal of Strategic Security* 12, no. 1 (2019): 16.

[53] Raphael S. Cohen et al., *Assessing the Prospects for Great Power Cooperation in the Global Commons* (Santa Monica, CA: RAND Corporation, 2023), 32, 33, 37.

[54] Cohen et al., 32.

[55] Kiseok Michael Kang, "Extended Space Deterrence: Providing Security Assurance in Space," *Journal of Strategic Security* 16, no. 2 (2023): 14.

Although an antisatellite missile may be easy to attribute, countries such as China have recognized the long-term effects of the resulting debris field and have switched to ground-based weapons such as lasers and jammers.[56] These weapons allow for the covert destruction of adversary satellites with minimal risk of attribution. Even as China publicly states its commitment to the Outer Space Treaty, it maintains the ability to control access to space through these weapons.

Likewise, proportionality is a key concern. Many adversary states have a limited space presence and are less reliant on space than the United States. Red lines based on mortal threats to humans in space are impractical because most objects in space are uncrewed. Therefore, committing forces in retaliation for an attack on a satellite is most likely not politically viable.[57] Also, retaliating against a state less reliant on space-based technology may fail to produce the desired deterrent effect.[58] With these concerns in mind, how can the command navigate the modern multipolar world, where each state has myriad unique problems and needs, to deter space aggression?

As Brodie developed his nuclear war theory, part of his analysis centered on the issue of aggressor versus defender. He found defenders have a much easier time deciding to engage in violence than aggressors.[59] This is partially because aggressors, to some extent, realize they are "disturbing the status quo in a way that could produce a war."[60]

Continuing this thought, he examined the idea of shooting first and whether it mattered in the context of a broader conflict. He determined it was a detail easily obscured and rendered irrelevant within the broader context.[61] Indeed, if a belligerent used nuclear weapons as the first shot, some attribution would enter the history books. Yet would it matter if the state shooting first claimed it was in defense of its territory and won the subsequent conflict? Had Able Archer 83 ended in nuclear war, history would be far more concerned with the resulting massive destruction than with who shot first.

Space Deterrence: Recommendations

As mentioned earlier, much of Brodie's analysis presupposed that the United States would interact with rational actors who were concerned with national survival and who were relatively predictable in their pursuit of that goal.[62] Yet as the Russian conflict in Ukraine has demonstrated, rationality is relative. What appears logical to one nation may seem irrational to another.

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[56] Cohen et al., *Great Power Cooperation*, 35.

[57] Kang, "Extended Space Deterrence," 19.

[58] Kang, 18.

[59] Brodie, *Escalation*, 45.

[60] Brodie, 45.

[61] Brodie, 45–46.

[62] Keith B. Payne, "The Great Divide in US Deterrence Thought," *Strategic Studies Quarterly* 14, no. 2 (Summer 2020): 18, https://www.airuniversity.af.edu/Portals/.

Rationality is unique to a given situation and is based on context and perspective, as Brodie eventually concluded.[63] Certain elements from Brodie's nuclear deterrence theory—diplomacy, resiliency, and situational rationality—are essential for discussing space deterrence. Diplomacy that works toward security agreements is the ideal outcome. But remaining vulnerable to catastrophic attacks can allow the opponent to make a rational decision to engage in conflict.[64]

While these might seem like disparate elements, US Space Command can leverage them into a cohesive deterrence strategy. This section will recommend two deterrence methods and two actions that the command can use to leverage the elements of nuclear theory in space. Satellites cannot withstand a missile strike, nonkinetic strikes can neutralize them for a period, and debris fields generated by missile strikes and nonfunctioning satellites would inhibit friendly and enemy satellites within a particular orbital path. Yet Space Command can turn these weaknesses into strengths.

Stratified Deterrence

Stratified deterrence is "a new deterrence construct which accounts for the changed world of the 21st Century" and which "addresses deterrence needs at each potential level of conflict."[65] Conceptualized as a model for nuclear deterrence, when applied to space, stratified deterrence begins with diplomacy. In the United States, public diplomacy belongs to politicians. Yet the military can and does engage in diplomacy, defined as "military communication and relationship building with foreign publics and military audiences for the purpose of achieving a foreign policy objective."[66] During Able Archer 83, diplomacy at all levels was focused on threatening the Soviets through military and other means. For a space deterrence strategy to work, however, military diplomacy must include the art of dissuasion by "offering reassurances and benefits that make a world without aggression more attractive."[67]

The next level of stratified deterrence features an array of kinetic and nonkinetic escalation options available to US Space Command. Scholars have proposed the special operations-cyber-space triad concept to meet the 2022 national defense strategy; however, organizational and operational doctrine currently limits this concept.[68] Yet

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[63] Payne, 32; Thucydides, *The Landmark Thucydides: A Comprehensive Guide to The Peloponnesian War,* ed. R. B. Strassler and trans. Richard Crawley (New York: Touchstone, 1998), 15; and Richard Ned Lebow, "Misconceptions in American Strategic Assessment," *Political Science Quarterly* 97, no. 2 (Summer 1982): 197.

[64] Everett C. Dolman, "Space is a Warfighting Domain," *Æther: A Journal of Strategic Airpower and Spacepower* 1, no. 1 (Spring 2022): 89, https://www.airuniversity.af.edu/Portals/.

[65] Brent J. Talbot, "Getting Deterrence Right," *Journal of Strategic Security* 13, no. 1 (2020): 34, 27.

[66] Matthew Wallin, *Military Public Diplomacy: How the Military Influences Foreign Audiences* (Washington, DC: American Security Project, 2015), 1, https://www.jstor.org/.

[67] Mazarr, *Understanding Deterrence*, 5.

[68] Will Beaurpere and Ned Marsh, "Space, Cyber, and Special Operations: An Influence Triad for Global Campaigning," Modern War Institute, September 6, 2022, https://mwi.westpoint.edu/.

there is still an opportunity for the command to leverage military alliances and cross-domain organizations to maintain escalation options.

Through ongoing military diplomacy, Space Command can quickly verify reports of adversary space actions to determine true intent.[69] With this information, the command can develop contingency plans to use cyber assets to attack an adversary's critical functions or deploy a Special Forces team against a ground space-support node. US Space Command can also use military alliances with friendly states to put pressure on an adversary from multiple sources.[70] This pressure could include suspending military training opportunities, withholding critical information, or denying support to continued space operations.

The final layer advocates "escalation dominance."[71] Using the triad mentioned above, Space Command can deter emerging space actors from aggression by threatening their fledgling space systems with various responses. The key is to position assets so that a nation contemplating an attack knows it will receive a swift response. Yet "deterrence by punishment" must be combined with ongoing dissuasion to enable a stable and peaceful space environment.[72] In short, the command must offer an array of carrots in addition to sticks, assuring continued access to and benefit from space as long as the space actor engages in responsible behavior.[73]

Dissuasion Deterrence

Dissuasion deterrence is a carrot-and-stick approach that seeks to "prevent an action by including steps to make an action unnecessary—including offering concessions or reassurances."[74] Threats of punishment are still part of this strategy, but they must be combined with an offer of benefits. One way to implement this form of deterrence is by building consensus on a space traffic management (STM) plan that includes both commercial and military spacecraft. A growing number of academics and commercial entities see the need for a viable international STM framework.[75] Additionally, US Space Command can work with the academic and commercial entities working on STM and space law doctrine to provide a military voice, ensuring national defense remains a priority.[76]

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[69] Joan Johnson-Freese, "China's Space Ambitions: It's Not All about the U.S.," *Georgetown Journal of International Affairs* 15, no. 1 (Winter/Spring 2014): 143–44.

[70] Moltz, "Changing Dynamics," 31.

[71] Talbot, "Getting Deterrence Right," 31.

[72] Mazarr, *Understanding Deterrence*, 2.

[73] Johnson-Freese, "Space Mission Force," 11.

[74] Mazaar, *Understanding Deterrence*, 5.

[75] See for example Brian G. Chow, "Space Traffic Management in the New Space Age," *Strategic Studies Quarterly* 14, no. 4 (Winter 2020): 77–78, https://www.airuniversity.af.edu/; and Bruce McClintock et al., "The Time for International Space Traffic Management Is Now," RB-A1949-1 (Santa Monica, CA: RAND Corporation, 2023): 3–4, https://www.rand.org/.

[76] Steer, "Global Commons,"14.

Through military diplomacy and building alliances, the command can also offer access to space situational awareness information, ensuring the safety of Ally and partner nations' space assets. This access can also be suspended or used as leverage to deter nonkinetic attacks. By building habitual relationships with spacefaring governments, the command can continue to reiterate the risk posed by acting irresponsibly in space, pressure potential attackers, and keep access to space open to all by marginalizing those who would compromise it.

The Able Archer 83 case study exemplifies the key role diplomacy plays in any deterrence strategy. An analysis of Able Archer 83 shows that one of the factors leading to heightened tensions was Soviet perceptions of US intentions.[77] Troop movements, nuclear launch rehearsals, overflights, and even Reagan's missile defense plan contributed to the Soviet perception of an imminent attack.[78] This perception changed in 1984 after Reagan learned how close the world had come to nuclear war and began diplomatic talks with his Soviet counterpart.[79]

As US Space Command works toward STM and improved space domain awareness, it must balance the effort with diplomacy to prevent the perception of excluding competitors from space. Narratives should build on the Outer Space Treaty to envision a space traffic management plan that allows current nonspace-capable nations to enter space in the future. Commercial and academic partnerships must also include foreign entities to create a shared understanding of the end product.

Resilience

US Space Command can take two approaches to increase its space resilience. One is to invest in the production of small, inexpensive, military-owned satellites to build a renewable mesh network that does not have a single point of failure. In past years, efforts such as Blackjack have provided this capability.[80] The goal is to secure the command's position in space, enabling a firm ground for diplomacy and providing a deterrent effect against attributable antisatellite attacks. The second approach leverages commercial satellite constellations and services to provide needed capabilities to other warfighting domains. By integrating "military, commercial, civil, and possibly allied networks" to create a layered and survivable system, Space Command can build a high level of resilience and maintain space superiority.[81]

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[77] "The Soviet Side of the 1983 War Scare," November 5, 2018, National Security Archives, https://nsarchive.gwu.edu/.

[78] Jones, *Able Archer 83*, 9.

[79] Barbara Farnham, "Reagan and the Gorbachev Revolution: Perceiving the End of Threat," *Political Science Quarterly* 116, no. 2 (Summer 2001): 232.

[80] Jon Harper, "DARPA Set to Deliver New Space Capabilities," *National Defense* 105, no. 801 (August 2020): 32, https://www.jstor.org/.

[81] Makena Young and Akhil Thadani, *Low Orbit, High Stakes: All-in on the LEO Broadband Competition* (Washington, DC: CSIS Aerospace Security Program, December 2022), 15, https://aerospace.csis.org/.

Control of Space

In terms of space, attribution is difficult, red lines are almost impossible to establish, and the question of proportional response is tricky. Given these conditions, one of the first steps the command must take to create a deterrent effect is to seize control of space.[82] This does not mean weaponizing space. Instead, US Space Command must embrace its role as the military leader in space and act decisively to negotiate rules and norms with Allies, partners, competitors, public entities, and private companies. This may include agreeing to measures limiting US capabilities, such as when Vice President Kamala Harris announced the end of US antisatellite weapons testing.

The issue of self-limiting leads to an important question that Brodie posed in 1965: "What did we do to make them think we would let them get away with it?"[83] The United States historically does not like to self-limit its options. Yet this also sets the standard by which others will follow. Although in the past, this has resulted in a negative action-reaction cycle, this could also work positively.[84] Able Archer 83 was the culminating event in an action-reaction cycle that stretched across Reagan's first term. After Reagan became aware of the situation, he shifted to a positive cycle hallmarked by discussions with Soviet leader Mikhail Gorbachev, contributing to easing tensions.[85]

US Space Command can continue building its network of alliances and friendly states by seizing control through leadership. Control can be bolstered by sharing information, increasing capabilities, and partnering with less technologically capable states. In doing so, the command can increasingly marginalize states that seek to weaponize space and leverage this network to attribute malign actions for quick response. As the final frontier becomes more congested and contested, US Space Command must lead the way to peacefully ensure the continued exploration and exploitation of space.

Conclusion

As shown, diplomacy at multiple levels is essential to a deterrence strategy. Adversary perception of military action during the lead-up to Able Archer 83 indicates that in the absence of active public diplomacy, the Soviets imposed meaning on the various US actions. This perception nearly led to nuclear war. Political diplomacy can be a highly charged endeavor, and active military diplomacy can help bridge the gap and reduce tensions, a role for which the command is uniquely situated.

A strategy of deterrence crafted by US Space Command should include stratified deterrence centered on three components: promoting active military diplomacy, building an array of response options, and maintaining escalation dominance. The command must also move beyond the single points of failure in its high-tech satellite array to embrace resilient networks of satellites that "can support their assigned mission

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[82] Dolman, "New Frontiers," 88.

[83] Brodie, *Escalation,* 20.

[84] Rathjens, "Dynamics," 19.

[85] Ambinder, *Brink,* 278–79.

despite an adversary's purposeful interference."[86] These concepts will defend against potential attacks on critical space assets and negate the advantage of surprise.

Yet it is essential to remember that these parts should not be employed separately; instead, the command should use all three simultaneously to dissuade an adversary, providing a form of dissuasion deterrence to prevent aggression.[87]

Deterrence in space is difficult. Maintaining a tenuous status quo, accurately attributing aggression, and properly gauging the proportionality of response present enormous challenges. The command should seize leadership control of space and work relentlessly to establish operating rules of space in coordination with Allies, partners, and competitors. Establishing the required alliances and agreements will help ensure aggression is rapidly identified, correctly attributed, and addressed under the terms of international law. As Brodie noted, "The control of escalation is an exercise in deterrence."[88] US Space Command must leverage its leadership role to build and maintain a deterrent effect against aggression.

Space appears endless, with room for an infinite number of objects. In reality, accessible and usable space is becoming congested, creating an atmosphere of competition that could quickly transition to kinetic conflict. An examination of nuclear deterrence theory and the unintended effects of military activity during Able Archer 83 help clarify the US role in contributing to destructive outcomes. Active diplomacy is a difficult endeavor but will lead to a positive and cooperative space environment that is far more enduring than one based on threats alone. ***Æ***

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[86] James P. Finch and Shawn Steene, "Finding Space in Deterrence: Toward a General Framework for 'Space Deterrence,' " *Strategic Studies Quarterly* 5, no. 4 (Winter 2011): 15.

[87] Mazarr, *Understanding Deterrence*, 4.

[88] Brodie, *Escalation*, 49.

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