Building U.S. Space Force Counterspace Capabilities: An Imperative for America's Defense

Col Charles S. Galbreath, USSF (Ret.)

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About the Author

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Cover design by Madeline Portway; Images: DOD, U.S. Space Force, ESA, and ESA

Contents

Foreword

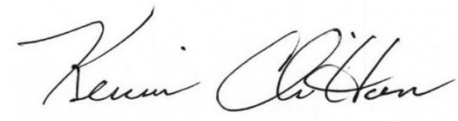
Space capabilities and services are integral to both modern life and modern warfare. This fact is demonstrated daily and over three decades of regional conflicts. Potential adversaries like Russia and China have witnessed the undeniable advantage free access to space has afforded the United States and our allies. That is why China, Russia, and others are developing, testing, and deploying weapon systems specifically designed to erase our nation's space advantage.

Compounding this problem is the alarming rate China is developing its own space capabilities to enhance their military operations and threaten our military forces with space-enabled attacks. A future conflict with China could be decided by which side can maintain their access to space while denying it to their adversary. In essence, the outcome of great power competition is about who can maintain space superiority.

The United States created the Space Force in response to this new reality. Securing U.S. interests "in, from, and to space" is foundational to the success of the U.S. military. However, the Space Force currently lacks the firepower commensurate with their charter. This is why the development of U.S. offensive and defensive counterspace weapon systems is vital. In this new high-water mark for the Mitchell Institute's Spacepower Advantage Center of Excellence (MI-SPACE), Charles Galbreath examines the historical and current challenges facing our nation and the Space Force. He provides an insightful perspective and comprehensive set of recommendations based on 30 years of spacepower experience.

This policy paper provides a clear plan for developing essential U.S. counterspace capabilities. As one of the first in-depth research projects on this critical issue since the establishment of the Space Force, it provides new insights and recommendations to guide national leadership, Congress, and the nation's newest military service. The report argues for increased investment in space domain awareness, satellite defenses, and offensive weapons to hold adversary space systems at risk. Implementing its recommendations would position the Space Force to deter aggression and protect service men and women who can't afford a "day without space."

Lt Gen David A. Deptula, USAF (Ret.)
Dean, The Mitchell Institute for Aerospace Studies



Gen Kevin Chilton, USAF (Ret.)
Explorer Chair, MI-SPACE

Key Points

All U.S. joint force operations depend on U.S. freedom of action in space, but adversary weapons, especially those fielded by China, are now capable of disrupting, degrading, and in some cases, defeating U.S. space systems that were designed for an uncontested operating environment.

Existing U.S. efforts to establish norms of responsible behavior in space and increase the resiliency of its space architecture are necessary but not sufficient to deter Chinese aggression in space credibly.

The U.S. Space Force must develop a suite of defensive and offensive counterspace systems to protect America's vital interests in space and defend against adversary space-enabled attacks.

The Space Force is stretched thin to meet its current operational requirements with a budget that is smaller than any other U.S. military service. Developing, testing, and acquiring counterspace capabilities and the forces to operate them will require additional funding and modest end strength growth to provide a responsible balance of capabilities and capacity to meet the growing threat.

Abstract

Space is on the front line of America's strategic competition with China. Capabilities in this domain are essential to the U.S. military's ability to deter threats and project war-winning combat power. The United States has designed and sized its military forces assuming they could depend on continuous access to space capabilities and effects. This assumption is no longer valid.

China has already fielded an alarming array of operational counterspace weaponry, including an arsenal of ground-launched missiles carrying anti-satellite kinetic kill vehicles, ground-based electronic warfare capabilities, and satellites capable of attacking U.S. assets in orbit. China has the most rapidly developing counterspace capabilities of any nation and is expanding its overall space program with the intent to surpass the United States.

It is not in the U.S. interest to see conflict in space. Existing U.S. efforts to promote norms of responsible behavior and increase the resilience of its architecture are necessary but not sufficient to deter the growing threat of Chinese aggression. Just like services in other domains, the U.S. Space Force must have a robust suite of defensive and offensive capabilities to credibly deter adversaries. Clear guidance, Congressional support, and unified Space Force and industry efforts are required to develop, field, and operate counterspace capabilities to enhance deterrence and create a war-winning force. Not taking this next step in the service's maturation risks a failure to deter China and will jeopardize the national interests of the United States.

Introduction

The U.S. advantage in space is at risk. While China's counterspace capabilities present the largest threat, other nations like Russia are also demonstrating their intent to deny their adversaries access to the growing benefits of commercial and international space systems and nullify the U.S. military advantage in space.

Since Operation Desert Storm, China and other potential adversaries have recognized the criticality of the space domain and the U.S. military's increasing reliance on space for satellite communications (SATCOM); position, navigation, and timing (PNT); intelligence, surveillance, and reconnaissance (ISR); missile warning; weather; and other missions. The People's Republic of China now believes attacking U.S. space systems is essential to prevailing in a conflict with the United States and is actively fielding the most extensive collection of counterspace threats of any nation. The ability to deter and, if necessary, defeat Chinese aggression in space will require a combination of all elements of U.S. national power, including a credible, effective U.S. Space Force with the right capabilities and force capacity.

The principles of deterrence are the same in all domains—it requires a credible Army, Navy, Air Force, and now a Space Force. The enormous responsibility of protecting the expanding U.S. interests in space, deterring aggression in space, and continuing to conduct space operations that provide effects crucial to the success of all U.S. military operations now falls on the youngest, smallest, and least-funded military service.[1] The Space Force must be prepared and armed with sufficient resources and clear governing policies to conduct credible and decisive defensive and offensive counterspace operations.

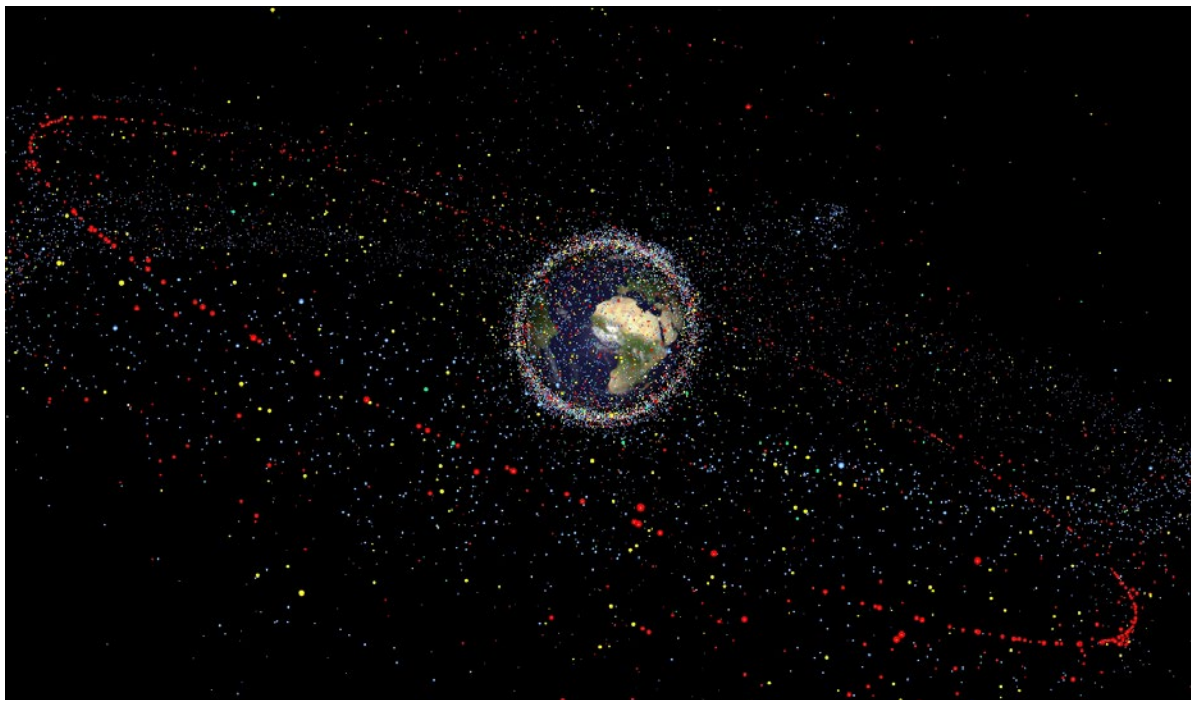


Image: European Space Agency (ESA). Illustration depicts distribution of space debris.

U.S. Space Weapons: To Be or Not to Be?

The possibility of developing and fielding operational space weapons has been a national security consideration ever since the Soviet Union launched Sputnik in 1957. Changes to perceived threats and vital interests through the Cold War and beyond shaped U.S. policies on these capabilities. For example, the United States pursued the development of weapons in space to defend against Soviet nuclear ballistic missile attacks as part of the Strategic Defense Initiative, also known as the "Star Wars" program. Then, from the end of the Cold War until recently, the U.S. Government believed there were few serious threats requiring it to pursue space defenses. The United States also sought to preserve stability in space and did not want to be viewed as an aggressive "first mover" in the development of space weapons that could disrupt the status quo. As a result, the Department of Defense (DOD) canceled its Cold War-era space weapons programs.

The Commission to Assess United States National Security Space Management and Organization voiced significant concern on this issue in early 2001. Their report warned that growing trends, including threats posed by China to U.S. space systems, required new policies and the development of space capabilities to defend U.S. assets in orbit.[2] However, the September 11, 2001, terrorist attacks on the United States and DOD's subsequent focus on counterterrorism operations overshadowed concerns about protecting U.S. access and freedom of action in space. Discussion on the need to develop space weapons bordered on the taboo, as many U.S. national security professionals continued to believe they were too far off, too costly, or would be too bellicose an action for a domain that was still relatively permissive.

What is a "Space Weapon?"

For the purposes of this paper, a "space weapon" is a device or system operated in, to, or from space used by a combatant to disrupt, damage, or destroy an adversary's capability. There are three basic operating modes of space weapon employment: terrestrial (ground, maritime, or air)-to-space, space-to-space, and space-to-terrestrial. Space weapons encompass a variety of kinetic and non-kinetic (e.g., radio frequency jamming, laser, cyber, or high-powered microwave) means of delivering temporary or permanent effects.

Attacks are considered "from space" if they begin from an orbital trajectory, even if the weapon does not complete an entire orbit, a capability known as fractional orbital bombardment.

Finally, terrestrial weapons attacking terrestrial targets can achieve a space effect but are not considered space weapons (e.g., destroying a ground station with a hellfire missile launched from a Predator).

While many in the U.S. national security community continue to shun the topic of space weapons, the fact is there are remarkably few explicit limitations on space weapons development. The Outer Space Treaty of 1967, which has 113 signatory countries, including the United States, Russia, and China, prohibits placing nuclear or other weapons of mass destruction in orbit or on celestial bodies.[3] The United States has unilaterally decided not to test systems like direct-ascent kinetic interceptors that would generate long-lived debris. While there are conventions related to the liability of actions, there are no formal internationally recognized agreements prohibiting the development and fielding of space weapons.[4] Furthermore, since international law originates from international conventions, general principles of law, and international custom or practice, Russia and China's placement of weapons in orbit and their fielding of direct-ascent kinetic interceptors are actually laying the legal framework to normalize space weapons.[5]

Potential adversaries have been exploiting the lack of clarity and an international prohibition against space weapons, while the United States chose self-restraint. The result is a precarious condition. Russia and China are developing and actively demonstrating fielded space weapons, including direct-ascent missiles, lasers, jammers, and a variety of co-orbital systems. In contrast, the U.S. space architecture was tailored to maximize the benefit of space as a peaceful domain—leaving it virtually defenseless and making it vulnerable to Russian and Chinese attacks. The disconnect between these two approaches now drives the Space Force to rapidly adjust to the reality of space as a warfighting domain and address the threats posed by Russia and China.

Ramifications of Ignoring the Threat: A U.S. Space Architecture Optimized for a Sanctuary

A decades-long view of the space domain as an operational sanctuary continues to profoundly impact and constrain the development of U.S. systems and associated operations, leaving them vulnerable and ill-suited to the current reality of space as a warfighting domain. The U.S. military developed its space architectures around small numbers of highly capable, very expensive satellites and related systems based on the belief that man-made threats to space capabilities would be negligible. In a peaceful space environment, there was no need to provision these capabilities with onboard defenses. As a result, many of DOD's exquisite space systems are now "big, fat, juicy targets" for emerging Chinese and Russian counterspace forces.[6]

Since Desert Storm, the U.S. military continued to emphasize the fielding of exquisite satellite systems and their integration to support air, ground, and naval operations. For example, organizations like the Space Warfare Center did not explore the possibilities and ramifications of conflict in space but instead concentrated on integrating space into the full spectrum of U.S. military operations. This fostered incredible advances in space capabilities, such as precision guidance and global communications, which enabled the U.S. military to transform how it conducted ISR and precision strikes, as well as how it sized its force structure. U.S. operations in a series of regional conflicts during this period, such as the air operations over Bosnia, highlighted the benefits of space integration. However, as capable as these exquisite space systems were, they are now also incredibly vulnerable to emerging threats.

Because the United States prioritized maximizing mission performance, many of its satellites lacked even basic defensive capabilities, like maneuverability to avoid threats. Since launch vehicle capacity often constrains satellite size and weight, developers must optimize and make trade-offs among satellite subsystems. A common trade-off was between the weight allowed for fuel and the weight allowed for mission payloads. For most U.S. satellites, fuel stored onboard is intended to position them in proper orbits after launch, periodically perform station-keeping maneuvers to maintain their position and attitude while on orbit, and for end-of-life maneuvers to deorbit or move to a disposal orbit. Trading off satellite fuel to increase payload capacity did not create substantial operational problems in a space environment where other significant maneuvers, for example, to manage constellation configuration, were rare. As a result, most satellites in operation today have very limited fuel capacity and therefore limited ability to avoid potential threats. Circumstances now demand greater agility and defensive capabilities. It is not just the satellites that are ill-equipped for a warfighting domain; the supporting infrastructure also has significant limitations and vulnerabilities.

Adversaries with counterspace capabilities can now exploit lengthy delays between observations and existing regional gaps in U.S. space sensor coverage to conduct operations to threaten U.S. satellites. Since satellites rarely maneuvered, knowing where a satellite would be at a given time in its orbit was highly predictable. This predictability required only a handful of globally dispersed space surveillance sensors to perform periodic satellite tracking. The DOD could tolerate regional gaps in coverage because the surveillance network simply needed to ensure satellites and debris were located where they were supposed to be. When a satellite maneuvered unexpectedly, space surveillance network (SSN) sensors would have to search a wider and wider region around the satellite's expected position until sensors detected it and the DOD updated the space tracking catalog. This search consumed sensor capacity, meaning the SSN could not perform scheduled collection on other orbiting objects, increasing the potential for additional lost tracks. Congestion in the space domain increased over time as more countries and organizations became spacefaring and as irresponsible anti-satellite (ASAT) tests by Russia and China created more debris. This stretched the limited capacity of the SSN further, decreasing the number and frequency of observations it could perform on any one space object. This, along with the existing regional gaps in coverage, enable adversaries to exploit the limitations of the legacy SSN.

Similarly, the operations of U.S. satellites—their telemetry, tracking, and control (TT&C)—are based on establishing periodic contact between satellites and operations centers to transmit commands, perform status checks, and download mission data. Like the SSN, the satellite control network (SCN) consists of a few globally dispersed ground stations. Prolonged periods without contacts are standard practice for satellites in predictable orbits conducting routine operations. These periods of no contact became longer as the number of U.S. satellites on orbit grew and their operators competed for access to the limited SCN. Longer "no contact" periods also create windows of opportunity for an adversary to attack a satellite and reduce the U.S. military's ability to respond immediately.

The Pacing Threat for the U.S. Space Force

The number of potential adversaries able to threaten space systems and the sophistication and capacity of those threats are rapidly increasing. From widely available radio frequency (RF) jammers to co-orbital threats posed by Russia and China, the threat landscape is daunting. These threats are not speculative: they have already manifested. For example, in their invasion of Ukraine, Russia conducted cyber and RF jamming attacks to negate Ukraine's access to satellite communication and the Global Positioning System (GPS) navigation and timing signals. While the threat landscape grows and the potential for proliferation to more nations exists, China is the most stressing threat.

From the first day he took office, Secretary of the Air Force Frank Kendall's priorities for the Space Force and Air Force were crystal clear: "in order, … China, China, and China."[7] China now poses a complex and formidable pacing threat for the development of the Space Force's capabilities and force capacity. According to the 2023 Annual Threat Assessment of the U.S. Intelligence Community, "China is steadily progressing toward becoming a world-class space leader, with the intent to match or surpass the United States by 2045."[8] While this may seem like a distant date, it is only 22 years away—the same amount of time since the 2001 attacks on the Pentagon and World Trade Center. As the DOD focused for nearly two decades on counterterror and counterinsurgency operations, China accelerated its efforts to compete with the United States, develop its own capabilities to leverage the space domain, and field multiple offensive weapons to target U.S. and allied satellites.[9] These fielded weapons include ground-based electronic warfare, directed energy, and kinetic ASAT missile systems. They also demonstrated technologies related to on-orbit counterspace weapons.[10] During Congressional testimony in March 2023, Chief of Space Operations General Saltzman said that in addition to counterspace lasers and jammers, China had tested on-orbit grappling satellite systems, which could be weaponized to physically control or move other satellites in geosynchronous orbit (GEO).[11]

When discussing this topic, it is important to remember a key difference between China and the United States: China does not distinguish between its military and civil space programs. The People's Liberation Army (PLA) has purview over the planning and direction of all Chinese space activities, even scientific missions.[12] Any growth in China's space programs should be considered an expansion of its military space capability.

China's Perspectives on Space Deterrence are Starkly Different than America's

The differences between America's and China's conceptions of space deterrence help explain why China continues to develop counterspace capabilities and the United States has not. According to the Air Force's China Aerospace Studies Institute (CASI), China believes space deterrence is achieved through forceful persuasion. As their spacepower doctrine explains, "Space deterrence signifies having powerful space forces as backing and threatening to use or actually using limited space forces to awe and contain the opponent's military activities."[13] China would employ four escalatory stages to achieve its "space deterrence" objectives:[14]

- The first stage is a "show of space strength," which means that China believes by showing the strength of its space forces, it can deter would-be adversaries from taking aggressive actions in space or on Earth. This could be achieved by demonstrating its direct-ascent kinetic energy (KE) ASAT capabilities or satellites with robotic arms.

- As a potential crisis escalates, China next plans to demonstrate its prowess through "space military exercises." This second stage is consistent with Chinese activities in other domains, such as the recent PLA naval exercise encircling Taiwan.[15] For space deterrence, they would likely engage in a relatively aggressive "exercise" with their space forces, either in isolation or in conjunction with other forces.

- China's third stage is to change the disposition of its space forces by launching additional space assets or repositioning its existing space capabilities. China considers this a medium-high level deterrence action that has the added benefit of creating a favorable space posture if the situation escalates to combat.

- Lastly, China views an "over-awing space strike" as the fourth and final stage of space deterrence. This could potentially be a simultaneous attack against multiple U.S. space systems using a variety of weapons—what the Space Commission warned as a "Space Pearl Harbor."[16] While the previous three stages are analogous to steps the U.S. military might take in a crisis, preemptive strikes to deter an adversary are a complete anathema to the U.S. concept of deterrence in which a strike means deterrence had failed. The U.S. would likely view a Chinese attack against its space capabilities, especially an over-awing one, as a first strike in an all-out war instead of the last step of deterrence intended by China. This could lead to a conflict that would have devastating consequences for both the United States and China.[17]

Targeting the U.S. Advantage: China's Mounting Space Warfighting Capabilities

According to open-source intelligence reports, China has the most rapidly developing ASAT and counterspace capabilities of any nation.[18] These counterspace capabilities include weapons that create kinetic and non-kinetic effects through reversible or irreversible means to achieve Chinese objectives in times of crisis or war.

China has already fielded an alarming array of operational counterspace weaponry, including an arsenal of ground-launched missiles carrying ASAT kinetic kill vehicles (KE ASATs), cyber capabilities, and ground-based electronic warfare capabilities.[19] The PLA has demonstrated its KE ASAT weapons can now threaten U.S. space systems located in low Earth, medium Earth, and geosynchronous orbits. It also has operational units that use radio-frequency jamming to disrupt satellite communications, navigation, missile warning, and other vital space capabilities. Additionally, in the early 2000s, the PLA fielded ground-based lasers in at least two sites, Korla and Bohu, that are capable of temporarily blinding or permanently disabling satellites.[20] In 2006, the PLA deliberately lazed a U.S. National Reconnaissance Office satellite, which U.S. officials characterized as a "test."[21] These types of tests are not limited to lasers. General DT Thompson, the Vice Chief of Space Operations, stated in 2021 that Russia and China now conduct laser, RF jamming, and cyber-attacks against U.S. satellites "every single day."[22]

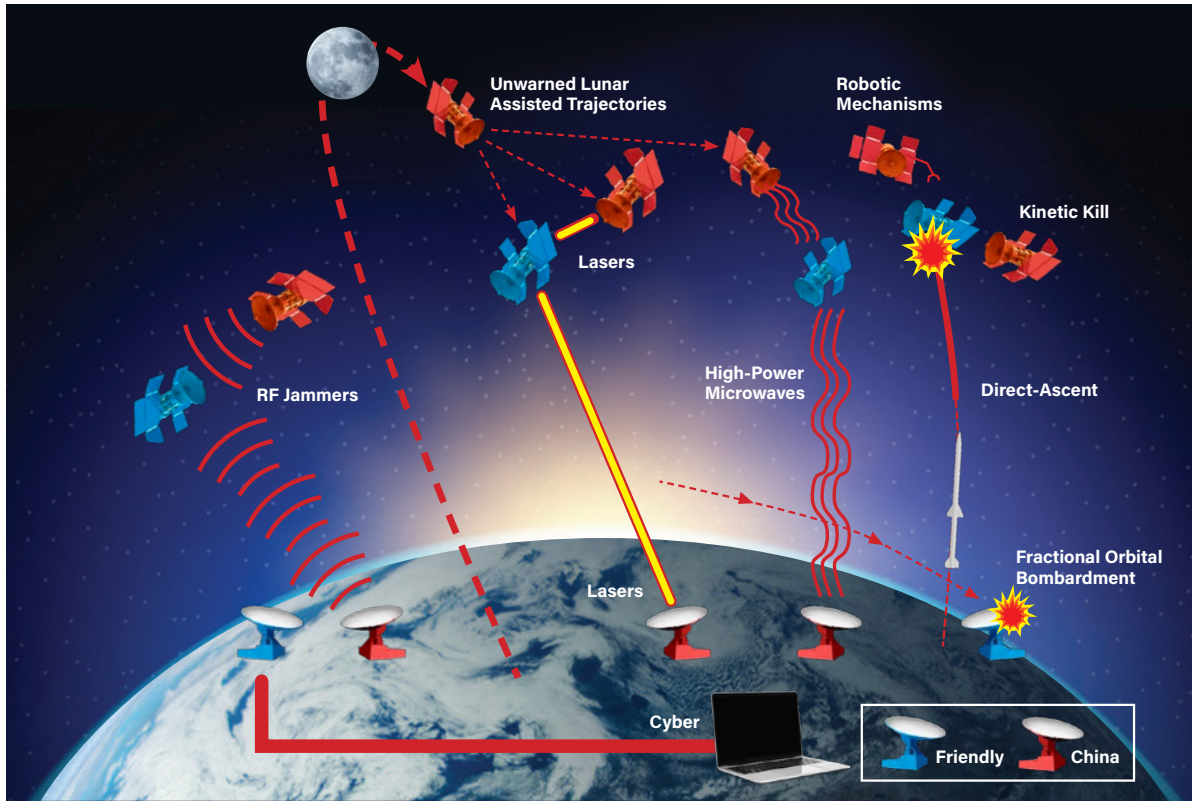


Figure 1: China's kinetic and non-kinetic (like cyber, RF jamming, and directed energy) counterspace capabilities threaten U.S. space systems in all orbits.

Source: Mitchell Institute

The PLA is also developing and testing additional space weapons. They have demonstrated satellites that can rendezvous with orbiting U.S. satellites and attack them using robotic arms or electronic warfare.[23] Open-source reporting claims that China has a megawatt-class solid-state laser and high-powered microwave systems that can all be mounted on satellites.[24] It has also developed a miniaturized power source for 10-gigawatt microwave weapons that can be mounted on a truck or rooftop to attack satellites.[25] Whether or not these capabilities are now operational, or even possible, is not confirmed, but they do serve as a clear indication of China's intent to develop the world's predominant counterspace force. Finally, in 2021, China demonstrated a nascent fractional orbital bombardment system (FOBS), which can launch weapons such as hypersonic glide vehicles into orbit and then de-orbit them to destroy ground targets.[26]

China is also demonstrating its intent to gain an advantage in cislunar space—the area between the Earth and the Moon—which could prove consequential for U.S. national interests and operations closer to Earth. China has already deployed a communication relay satellite on the far side of the Moon and announced its plans to deploy the initial phase of a combined lunar navigation and communication system in lunar orbit in the next few years.[27] While this may seem like a benign scientific endeavor, it has significant military implications. For example, changing the inclinations of space weapons in Earth orbits may be necessary for China to threaten some U.S. satellites. A maneuver like this may require a satellite to consume much of its propellant. However, China could launch satellites into cislunar space and use the Moon's gravity to help change their orbital paths to attack vectors while providing

little to no warning to the United States.[28] Having an existing navigation and communication capability around the Moon makes this possible for China. The United States will have challenges overcoming Chinese technological and operational advantages in this region given the long-lead development required to sustain cislunar operations. As with most space challenges, the key to mitigating them tomorrow is by considering solutions today. But it's not just China's counterspace capabilities that are concerning; it is also the pace and manner of their overall growth in space.

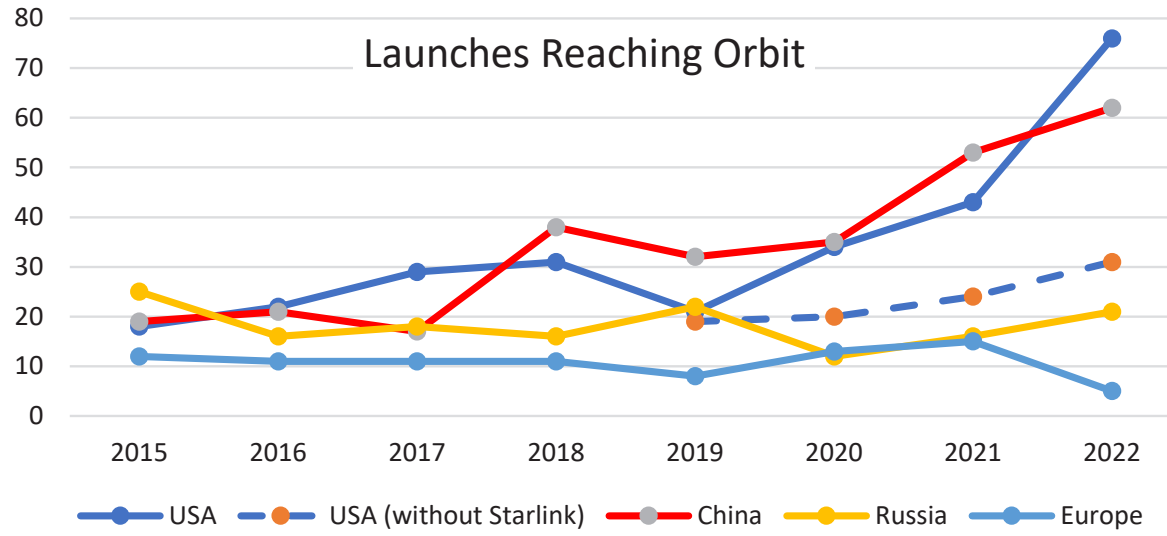


Figure 2: The comparative numbers of successful launches by nation. The dashed line represents U.S. launches minus the launches by SpaceX dedicated to deployment of the Starlink mega-constellation. Since 2018, China consistently outpaces Russia, all of Europe, and the adjusted U.S. launch rate—a clear indication of China's rapidly expanding use of space.

Source: Mitchell Institute

Seeking Their Own Advantage: China's Increasing Space Capabilities

China is now the second most active country in space behind the United States in terms of space launch, operational satellites, and capabilities. Consider the Chinese space program's rapid advances by comparing launches of satellites that reached orbit by the United States, China, Russia, and all of Europe from 2015 to 2022: during this period, China consistently had more launches than the United States, with a total of 277 versus 274 U.S. launches. This comparison is especially compelling considering 45 of the U.S. launches in 2022 were SpaceX launches of its Starlink satellites. In 2022, China placed 45 military payloads in orbit compared to 32 payloads by the United States.[29] These Chinese payloads include intelligence, navigation, communication, and potentially counterspace systems, all of which are now integrated into PLA military operation plans.[30] 2022 was not a fluke. It represented a continuation of China's surge into space. Between 2019 and 2021 alone, China expanded its space architecture by more than 50 percent, resulting in 541 operational satellites.[31] China also plans to directly compete with Starlink by launching a constellation of 13,000 satellites to provide communications and track, monitor, and potentially disable Starlink satellites, according to the Chinese project leader.[32] This last point, the ability to "disable" a commercial system, is particularly concerning and speaks volumes about China's intent and mindset.

While China's space advancements are impressive, it is important to recognize that many result from emulating the path charted by the United States. This has empowered them to rapidly develop their forces at lower risk and cost, resulting in parity with U.S. systems. For instance, China has now flown its own version of a highly maneuverable space plane, like the United States' X-37B. The latest mission of the Chinese space plane lasted 276 days in low Earth orbit (LEO) and deployed a small free-flying satellite operating near the Chinese space plane.[33] Little else is known about the capabilities and mission of the Chinese space plane, but it does illustrate the desire of China to rapidly gain equivalency and then surpass the United States.

Collectively, fielded and emerging PLA space systems and weapons pose a considerable challenge to continued U.S. operations in space and other national interests. The multitude of Chinese counterspace threats is directly in line with its escalation-based view of deterrence.[34] China has demonstrated its willingness to resort to shows of force, and it has exercised its capabilities and ability to maneuver its space assets. The United States must now be ready for a Chinese over-awing space strike that could begin a major conflict.

What's At Stake?

Military Operations at Risk

Today, space-based capabilities are essential to the U.S. military's ability to project influence and combat power at a time, place, and manner of the nation's choosing.[35] The United States has designed and sized its military based on the assumption it could rely on uninterrupted access to space capabilities and effects. Without freedom to operate in space, the United States cannot operate effectively in any warfighting domain.[36] Space capabilities, fielded and operated by the United States Space Force, enable joint lethality and the warfighting effectiveness of the Army, Navy, Marine Corps, and Air Force. By attacking critical U.S. space systems, China could reduce the American military's overall ability to see, communicate, navigate, project power, and command and control its forces. The net result would be American Soldiers, Sailors, Airmen, Marines, and Guardians at increased risk from attack and unable to prevent China from achieving its objectives. For instance, consider the loss of two space-based capabilities: missile warning and PNT. Losing either could have devastating, potentially decisive consequences for U.S. military operations.

Space-based missile warning, currently provided by the USSF's Space-Based Infra-Red Satellite (SBIRS) constellation in geosynchronous orbit, delivers initial indications of ballistic missile attacks by detecting the heat signatures of launching missiles. This indication is passed to fielded forces, allowing for personnel to seek shelter; to terrestrial radars for midcourse tracking; and to defensive systems like Patriot, Theater High Altitude Area Defense (THAAD), Aegis, or Ground-based Midcourse Defense (GMD) in order to attempt an intercept.[37] Without the initial cue from SBIRS, the amount of warning time provided to friendly fielded forces would be drastically reduced. It would also increase mid-course tracking challenges and greatly degrade the effectiveness of missile defenses. The net result is more U.S. and allied lives at risk.

The potential loss of PNT services provided by Space Force GPS offers another stark example. Localized GPS interference of the type that China, Russia, and others have already demonstrated could disrupt U.S. military logistics operations and navigation by its land, sea, and air forces. It could also degrade the accuracy of GPS-guided munitions, requiring additional sorties to strike targets, thus placing more American and coalition aircrews at risk and increasing the potential for collateral damage. An even more devastating reality would unfold if China attacked the entire GPS constellation. Not only would military operations become more difficult, but the entire global economy would also stagger since GPS provides the timing signal used to synchronize power grids, global banking, and communications and enables the local, regional, and global shipment of goods. There is hardly an aspect of modern life that wouldn't be impacted by the loss of GPS.

While these two examples are compelling, they only speak to half of the problem. China has rapidly grown its own space architecture to afford them the same benefits from space the United States now enjoys. This rough parity would be maintained in a conflict if neither side attacked the other's space systems. By denying the United States freedom of action in space, China would gain a decisive advantage thanks to the retention of its capabilities on orbit. A China that is capable of using space-enabled attacks with impunity to hold U.S. joint and allied operations at risk is a prescription for defeat. The United States must take urgent action to respond to this mounting threat or risk losing its ability to deter Chinese aggression and maintain peace in key regions around the globe.

The Growing Commercial and International Space Sectors

Concurrent to the military space development and mounting threats are the booming commercial and international space sectors—underscoring the need for the Space Force to protect expanding U.S. interests in space. These emerging markets are increasingly critical to the economy and other national interests of the United States. The Space Force preserves the space domain and maintains access to commercial and international space capabilities by demonstrating responsible behavior and promoting stability by fielding the means to deter aggression.[38] In many ways, this is comparable to the U.S. and allied navies preserving free and unfettered access to the sea for commercial mariners while also being prepared to engage militarily when and where necessary. In the face of both increasing commercial activities and threats, the Space Force must seize opportunities and overcome challenges to preserve free and unfettered access to the space domain.

On the one hand, international partners and commercial space companies now offer a considerable set of capabilities to support the Space Force and U.S. national security objectives. Breakthroughs in digital technology and a reduction in launch costs ushered in the growth of the space industry. Once the sole purview of global superpowers, the availability of inexpensive yet highly capable components has resulted in the expansion of spacefaring nations, private organizations, and academic institutions. Commercial and international partners can now provide communication, intelligence, weather, space domain awareness, and launch services. These capabilities can augment Space Force systems or provide a means to restore a lost or degraded functionality if an adversary successfully attacks a military system. According to Lt Gen Guetlein, the Commander of Space Systems Command, the Space Force is already purchasing approximately $4B per year in commercial space capabilities and plans even more through the establishment of the Commercial Space Marketplace for Innovation and Collaboration.[39]

On the other hand, the growth in commercial and international space activities creates additional planning factors for the Space Force. Unlike other domains where planners can at least partially segregate military operations from civilian activities, in space, commercial, civil, foreign, and military activities all constantly share the same domain. Consider that in 2022, countries and commercial companies around the world conducted 177 launches that placed 2,215 payloads into orbit. As a result, the Space Force is now tracking approximately 48,000 objects in space.[40] This explosive growth increases the strain on the limited tracking capacity of the SSN. Further, since the Space Force must protect U.S. national interests in space, this extends to U.S. economic interests. The current global space economy is $447 billion and is on a trajectory to reach $1 trillion by 2030.[41] If China conducted a kinetic attack against a U.S. satellite, the resulting debris could damage a wide range of commercial and international satellites that would have a devastating impact on the U.S. and global economies. The responsibility to protect these assets and the domain itself by deterring China from conducting such attacks falls to the Space Force. Similar to terrestrial domains, the ability to deter aggression in space will require the Space Force to have the right mix of defensive and offensive capabilities.

The Current U.S. Response to Space Threats

The United States has undertaken a multi-pronged approach to ensure its freedom of operations in space. Diplomatically, it is developing and calling for other nations to agree and comply with norms of responsible behavior in space. Militarily, it is developing capabilities to deter aggression and preserve stability in space. Neither approach by itself will successfully ensure the United States will have continuous access to and unimpeded use of space. Only a robust, full-spectrum approach offers the greatest likelihood of success. It must include efforts to establish international norms, increase resilience, develop the means to detect and defend against adversary space attacks, and field capabilities to deny adversaries the ability to exploit space in a manner threatening U.S. security.

Diplomatic Efforts to Establish International Space Norms

Driven by White House leadership through the National Space Council, the United States is making concerted efforts to normalize global space operations and activities to promote stability for national security, science, and commerce. The recent growth of the commercial and international space industries, and corresponding congestion in space, have increased the importance of adopting common standards of conduct for all spacefaring nations and organizations. As in any domain, the development of standards of responsible behavior and norms—like air traffic control procedures or international rules for navigating ships at sea—promotes safe utilization of that domain for all.

One of the most pressing norms sought by the United States is an international agreement to forego destructive, direct-ascent anti-satellite missile tests. In early 2022, Vice President Kamala Harris announced the U.S. commitment to prohibit such tests and called on other nations to voluntarily make similar commitments.[42] The main concern with these tests is that they will create long-lived debris in space that could affect all spacefaring nations. Unlike other domains where debris from explosions or impacts eventually settles to the surface of the Earth in a relatively confined area, debris can persist and expand across an extremely large volume of space. Increases in debris and the number of operational satellites raise the probability of collision in space and would force launch vehicles to travel through congested regions. In a worst-case scenario, debris could spread and destroy other objects in a cascading manner known as the Kessler Syndrome.[43]

The past four decades have provided multiple examples of accidental and intentional debris-generating events highlighting the criticality of this issue. In 2009 the deactivated Kosmos 2251 and Iridium 33 satellites collided, generating over 1,800 pieces of debris, with some pieces expected to stay in orbit through the end of the century.[44] While there are other examples of accidental debris generation from anomalies, intentional acts causing debris rightfully garner the most attention. In a 1986 test, the U.S. launched an anti-satellite missile from an F-15, which generated 287 pieces of debris, the last of which didn't re-enter the Earth's atmosphere until 2004. In 2008, the United States used an SM-3 missile to destroy a non-functioning satellite carrying a fuel tank of hazardous propellant in Operation Burnt Frost to eliminate the risk of the tank impacting in populated areas. By carefully selecting the geometry of the engagement, the United States destroyed the fuel tank and ensured the resulting debris did not persist or present a threat to other nations' satellites.[45] This event only generated 175 pieces of debris,

all of which re-entered the atmosphere by late 2009. By contrast, in 2007, China tested its KE ASAT weapons that generated 3,536 pieces of debris. Only 750 of these objects had re-entered the atmosphere as of February 2023.[46] The international condemnation of China's test was nearly universal. Since 2007, China has conducted seven more direct-ascent anti-satellite tests, none of which created debris or resulted in impacts on other satellites. China may have avoided creating space debris during these tests because of the outcry over its 2007 intercept and its desire to be considered a world leader in space—or it could be an indication China achieved all its objectives, technical and political, with its first kinetic intercept. India in 2019 and Russia in 2021 also conducted KE ASAT weapons tests. The India test resulted in 130 pieces of debris that have now re-entered, and the Russian test created 1,790 pieces of debris, with 300 pieces still in orbit. The amount and persistence of debris generated by these tests have proven two things. First, there are differences in the employment methods that increase or decrease the debris generated. Second, if irresponsible activities continue, the Kessler Syndrome will be a very real concern, especially to organizations and countries fielding mega constellations like the United States.

The good news is the U.S. declaration that it would not conduct additional debris-generating, direct ascent anti-satellite tests led twelve other nations to make similar pledges. The United Nations (UN) General Assembly also passed a resolution for countries to forego debris-causing direct-ascent KE ASAT tests, with 155 nations voting in favor, nine against, and nine abstaining. Notably, China and Russia voted against the measure, and India abstained.[47]

China and Russia have a history of rejecting the West's call for space norms and limits while putting forward their own self-serving versions. In 2008, they proposed to the United Nations the "Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat of Use of Force Against Outer Space Objects," commonly referred to as PPWT. However, PPWT lacked any prohibition against the development and stockpile of direct-ascent KE ASATs. This and other key failings led the UN to reject PPWT. Russia and China tried to submit updated versions in 2014 and again in 2021.[48] The 2021 PPWT called for no first placement of co-orbital weapons in space even though both China and Russia already had deployed weapons in space. Russia also

Kessler Syndrome

Image: ESA. Explosions of satellites and rocket bodies. See also Michelle La Vone, "Kessler Syndrome," *Space Safety Magazine.*

This syndrome is named after Donald J. Kessler, who described in 1978 how space debris could create a cascading set of collisions between satellites in LEO. The number of debris objects would increase with each additional collision creating an ever-growing debris field. Satellites and debris in LEO travel at approximately 17,500 mph, so even a small piece of debris can have a catastrophic effect on satellites. Unlike on Earth, where debris from a collision or explosion is localized and quickly falls to the Earth's surface, debris in space can persist for decades. With the growing number of satellites in LEO and the amount of long-lived debris caused by irresponsible behavior, the probability of collision increases.

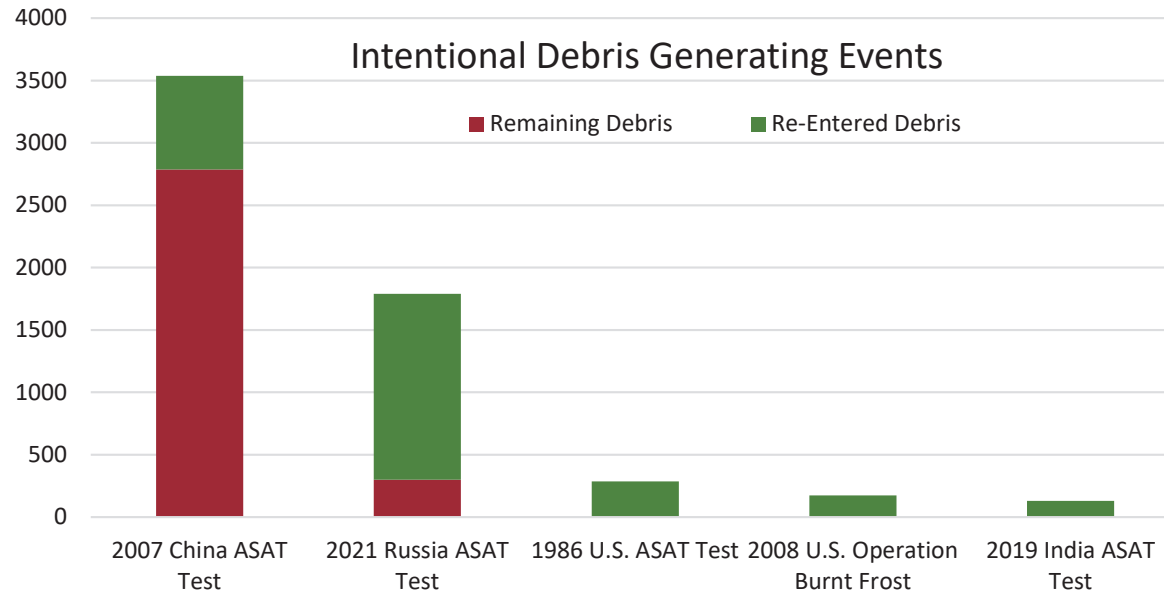


Figure 3: Comparison of debris generated from kinetic intercepts. As tracked by the SSN, the amount of debris initially generated and still persisting varies significantly between Chinese and Russian ASAT weapons tests and activities by the United States and India.

Source: Mitchell Institute

conducted its destructive ASAT test in 2021, which indicated a lack of commitment or sincerity.[49] China, for its part, seems to view norms as a means to constrain others from testing and deploying space weapons after it has already achieved technical and operational advantages.

There is a clear need for international norms and governance of activities in space that will help avoid miscalculations or escalatory actions in a crisis that lead to conflict. Potential areas for new norms include preventing other intentional debris-generating events, preserving globally used services like GPS, and non-interference with a nation's nuclear command and control or early warning systems. New norms must also include mechanisms to monitor their compliance and meaningful consequences for violations. However, while norms are on the critical path toward ensuring responsible operations for all spacefaring nations, norms alone are insufficient to deter or help defeat aggression in space. The United States also needs military capabilities to detect and respond to deviations from responsible behaviors in space—including deliberate attacks.

Space Force Actions

The Chief of Space Operations, General Saltzman, recently unveiled a framework called Competitive Endurance to guide Space Force plans to deter and, if necessary, defeat aggression in space.[50] Competitive Endurance, which is focused on ensuring U.S. access to space and preventing competition from escalating into conflict, has three core tenets: avoiding operational surprise, denying first-mover advantage, and responsible counterspace campaigning. The first two tenets continue efforts that predate the Space Force to improve space domain awareness and resilience. However, the third tenet, responsible counterspace campaigning, is a new area that will require further force capacity.

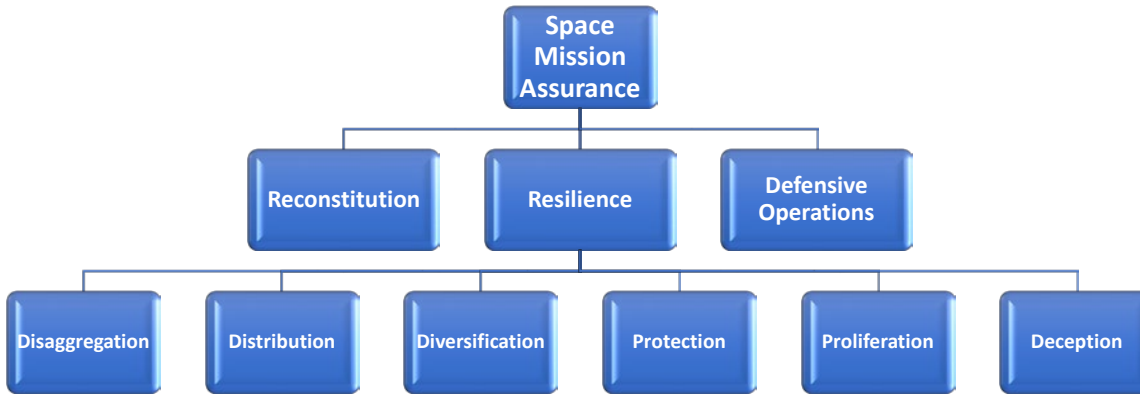


Figure 4: Space mission assurance taxonomy.

Source: The graphic is from DOD's 2015 white paper titled "Space Domain Mission Assurance: A Resilience Taxonomy."

Avoid Operational Surprise by Improving Space Domain Awareness

No military force wants to be surprised by an adversary. The need to understand a warfighting domain and the threats that exist in it is common practice for air, land, sea, space, and cyberspace forces. However, the space domain is unique because of the sheer vastness of military forces must consider and the lack of first-person awareness. Guardians derive everything they know about the space domain from data received via sensors and satellites. In a way, Guardians are always "flying on instruments" with data that is not real-time and may even be days old due to the limited capacity of the legacy SSN and SCN.

The concept of space domain awareness (SDA) takes this a step further by requiring the timely relay of information to enable Guardians to identify and develop appropriate responses to threats in space. Truly avoiding operational surprise requires additional sensors, analysis of the sensor data, and transmission to decision-makers in order to stay ahead of threats and preempt shifts in the space environment. When General Saltzman first unveiled the tenets of Competitive Endurance, he emphasized the need for new sensors and advanced data management and decision tools.[51] These are critical steps toward creating a force posture that will allow the U.S. Space Command to identify threats and related changes in space before they become crises. Achieving SDA is so critical that General Dickinson, the Commander of U.S. Space Command, consistently calls it his "top priority."[52]

In recent years, the Space Force has increased the number and type of systems supporting the SDA mission. The Space Force is now operating six Geosynchronous Space Situational Awareness Program (GSSAP) satellites to track and characterize objects in and around geosynchronous orbit.[53] In late 2022, the Australian Department of Defense and Space Force announced the U.S. Space Surveillance Telescope (SST) was operational. The SST was moved from New Mexico to Australia to provide a ground-based, broad-area search, detection, and tracking of faint space objects in the Indo-Pacific region.[54] This augments the Space Force's Space Fence radar system that has been operational since 2020 at Kwajalein Island in the Pacific.[55] An additional system, the Deep Space Advanced Radar Capability (DARC), will have three sites located around the world to further improve the U.S. Space Command's ability to track objects in GEO.[56]

Areas Needing Further Improvement

In many ways, GSSAP satellites, SST, and DARC sensors are needed simply to keep up with the increasing congestion in space. Additional sensors around high-value space assets and key regions in space, like GEO and cislunar, will be required to address the expanding number of adversary threats. Furthermore, the Space Force must make significant improvements in how it processes data from its sensors, and it must replace a number of its existing systems to make sense of information in the space domain provided by a growing number of sensor feeds. This is now performed by the Space Defense Operations Center (SPADOC) computer system, which became operational in the 1980s, and the Correlation, Analysis, and Verification of Ephemerides Network (CAVENet), which became operational in the early 2000s. Aside from their ages, each has significant shortfalls.[57] For instance, SPADOC, which General Raymond referred to as an "old clunker" in 2017, cannot perform complex processing or ingest data unless it is in a specific format.[58] CAVENet is an offline system requiring the manual transfer of data, which is clearly impractical for rapid response to threats. The good news is Space Systems Command (SSC) is working to deliver the Space Force new capabilities. Until a more responsive and capable processing system is online, though, the Space Force will have difficulty achieving the necessary level of space domain awareness required to counter an adversary in space.[59]

Increase Resiliency to Deny Adversaries a First-Mover Advantage

The Space Force readily recognizes that its architecture needs to be more resilient. As discussed earlier, the existing space architecture is vulnerable to a mounting array of threats, which creates an incentive for adversaries to attack quickly and degrade the U.S. ability to respond. This "offense dominant" condition equates to a first-mover advantage for an adversary and effectively invites, rather than deters, aggression. To deny this first-mover advantage, the Space Force must increase the resilience of its architecture, decrease the time to reconstitute it and defend its critical space assets to such a degree that an adversary loses confidence in its ability to effectively attack. The 2022 National Defense Strategy succinctly defines resilience in force design as "the ability to withstand, fight through, and recover quickly from disruption."[60] The criticality to improve the resilience of the space architecture came through loud and clear when Secretary Kendall unveiled his seven Operational Imperatives for the Department of the Air Force—topping the list was "defining resilient and effective space order of battle and architectures."[61]

Calls to increase the resiliency of the U.S. military's space architecture predate the Space Force. In 2015, the DOD released a white paper describing a taxonomy for resilience.[62] This thought piece suggested resilience, along with defensive operations and reconstitution, comprise a larger mission assurance umbrella necessary to guarantee that critical space systems would be available in a crisis or conflict and deliver essential warfighting effects. The United States can achieve this resilience for any element of the space architecture by actions in one or more of the categories, as demonstrated in Figure 4.

One of the earliest and most visible realizations of this shift is in the Space Development Agency's efforts to field a proliferated low Earth orbit (pLEO) constellation for missile warning. Proliferation, in this sense, means increasing the number of assets in a satellite constellation, and it makes the loss of a few assets tolerable because the constellation's overall level of performance stays above an acceptable threshold. The use of small, inexpensive satellites in a pLEO constellation also improves deterrence because of its increased cost imposition potential. The cost of a direct-ascent KE ASAT is now greater than the target satellite, and because of the sheer number

of assets an enemy must attack, proliferation reduces the effectiveness and impact of these weapons and other co-orbital threats. The Space Development Agency's pLEO system, coupled with existing U.S. GEO capabilities like SBIRS, further diversifies the missile warning architecture and improves its overall level of resilience.

While the pLEO approach garners a great deal of attention, it is not the only method the Space Force can employ to increase the resiliency of its architecture. Further diversification, distribution, and disaggregation methods can also improve the resilience of the space architecture. Additionally, the application of the enduring military practice of deception can confuse adversary understanding and complicate their ability to target U.S. satellites. As an example, the Space Force could construct satellite payloads or components in ways that would obfuscate their functions.[63] Finally, the Space Force can expand its use of protection measures such as nuclear hardening and anti-jam protection.[64] By including certain protection measures, the Space Force can create options for decision-makers to employ defensive operations—both a tenant of the mission assurance approach and an element of responsible counterspace campaigning.

Improving Resiliency Alone is Incomplete Mission Assurance

Collectively, the benefits from proliferated satellite constellations and other resiliency measures move the Space Force in the right direction. They may cause an aggressor to pause in a crisis and will complicate adversary planning and targeting. However, improving resiliency alone will not fully assure the Space Force's overall ability to perform its missions, and it will not markedly increase the survivability of U.S. legacy space systems that are still operational. Also, the unique mission benefits of operating satellites with sensors or communication capabilities in the GEO region are too great to abandon, so there will still be critical U.S. assets the Space Force must protect. Space Force mission assurance must go beyond resilience.

DOD's 2015 white paper described mission assurance as comprising resilience, along with the ability to reconstitute lost or degraded capabilities, and the ability to conduct defensive operations. The booming space commercial sector and growing allied capabilities can provide critical support to both resilience and reconstitution. As the Space Operations Command 2023 Strategic Plan states, "Space is a team sport—we will leverage our Allies' and Partners' capabilities to improve the resiliency of our architecture."[65] Leveraging commercial capabilities, such as SATCOM and imagery, are common for the military. For example, approximately 80 percent of the SATCOM used during Operation Enduring Freedom came from commercial providers. The proposed level of integration and use of hosted payloads is much more extensive in the Space Force's new approach, and while it does increase the resilience of the architecture, it also enables rapid restoration. The repositioning or use of allied or partner capability can effectively restore a lost or degraded Space Force system. A more ambitious method for reconstitution is the rapid launch of new satellites. The Space Force is planning to demonstrate rapid launch for an urgent need in the VICTUS NOX mission, which will deliver a space domain awareness satellite to orbit within 24 hours of notification.[66] While VICTUS NOX is characterized as an augmentation mission, the same approach can provide the needed restoration of lost or degraded capabilities.

This is all good news, but building pLEO constellations to increase resiliency and leveraging commercial systems will not be enough to deter or prevail against an aggressive, well-armed adversary in space. The Space Force's planners must also include passive and active defensive measures—defensive counterspace measures—to the service's ongoing resilience approach and its emerging reconstitution capabilities.

Responsible Counterspace Campaigning: An Area for Space Force Growth

The final and least developed area of the Space Force's Competitive Endurance initiative is the service's need to develop capabilities that can directly defend space systems and protect friendly forces from space-enabled attacks. The United States has largely shunned the thought of fielding space weapons since the end of the Cold War. However, recognizing space as a warfighting domain means any serious effort to achieve space security must include space weapons. It's oxymoronic to establish a new military service charged with protecting interests in space without arming it with the weapons it must have to accomplish its mission. Importantly, America did not choose this path; adversaries did. Now is the time to respond to deter potential outright hostilities. This said, another key U.S. space interest is to preserve the domain itself, which means U.S. defensive and offensive actions in space must minimize long-lived debris or other effects that would greatly degrade friendly space architectures. As Gen Saltzman put it, "We cannot have a pyrrhic victory in this domain."[67] This is why the Space Force calls this final element of its plan responsible counterspace campaigning. Even with this constrained approach, there must be no doubt in the mind of a potential adversary that the United States will take all necessary steps to protect its national interests and defend its fielded forces.

There was a brief window between 2006 to 2018, when China posed a counterspace threat but had not fully developed, deployed, and integrated its space forces, where a DOD resilience-only approach by itself was appropriate. However, China's own rapid fielding and integration of space capabilities now means the U.S. Space Force requires a new solution that includes offensive counterspace capabilities to deny China's space-enabled warfare strategy.

For years, the United States has possessed the Counter Communication System (CCS), which is a ground-based satellite communications jammer. This system can temporarily deny adversary communication signals without generating space debris.[68] It is also the first and, so far, only U.S. space offensive capability that may be able to partially deny PLA communications in localized areas and thus interrupt some PLA kill chains targeting U.S. and allied forces. However, CCS alone will not effectively protect U.S. space capabilities, nor does it have the capacity to hold the increasing number of Chinese space capabilities at risk. Responsible counterspace campaigning will require more.

Recently, Gen Saltzman unveiled that by 2026 the Space Force will have "a substantial on-orbit capability that allows us to compete in full-spectrum operations."[69] Details on this initiative will be forthcoming, but it seems clear the Space Force is working on a new satellite system to support its responsible counterspace campaign plans. This said, it's hard to envision a single additional system will be enough to address the scope and magnitude of threats and potential targets that are now confronting the Space Force. America's newest military service will require greater defensive and offensive counterspace capabilities and capacity to credibly deter attacks, protect U.S. space systems, and provide multiple avenues to impose costs against aggressors if necessary. This will require many specific capabilities to provide leaders with a robust range of policy options. China's aggressive programs to develop and integrate its own space warfighting capabilities continue unabated by any norms of responsible behavior in space. The margin of victory in a future conflict with China will increasingly hinge on the Space Force's ability to hold their assets at risk and defend U.S. and allied forces from PLA space-enabled attacks.

Changes Needed for Credible Counterspace Capabilities

The measures the Space Force is taking that empower Guardians to respond to adversary threats are critical. However, they represent the opening phase of what must be a far broader set of capabilities required to secure stability in space for the foreseeable future. Determined adversaries with an array of weapons will not be deterred by a single capability or approach. The Space Force must have the means to gain and maintain an advantage over potential enemies while still providing the essential space capabilities U.S. forces require for victory.

The objective of any military force is to gain and maintain an advantage over its adversary. Given the state of existing threats, only the inclusion of counterspace capabilities can create or maintain this advantage. This is not a "China has three ground-based lasers, so the United States must have four" argument that could lead to a tit-for-tat escalation or arms race. Rather, it is threat-based reasoning that the United States must maintain its access to space capabilities that are now threatened by China. And the United States must have the potential to deny China access to the space capabilities it needs to threaten U.S. space and terrestrial forces and national interests. Similar thinking is reflected in every other domain, for both empowering deterrence and facilitating actual warfighting capacity. Developing a Space Force with these capabilities will require political leadership, Congressional backing, industrial capacity, and Guardian action. These stakeholders must align to ensure America's warfighters can deter and, if necessary, defeat China's aggression in space. It all comes down to securing the military advantages and global benefits of the space domain that are vital to U.S. national security.

Adjust National and Military Policy

U.S. national policy must recognize the inability of norms and defensive measures alone to credibly deter threats or provide war-winning forces to defeat aggression in space. Space is now a warfighting domain, and there are ways to responsibly conduct warfare in space. National guidance and DOD policy must acknowledge these facts and direct the development of U.S. counterspace capabilities. Externally, this will send a clear message to potential adversaries that the United States is serious about defending its interests in space. Internally, it will provide a unifying and enduring way ahead to develop a future force that assures U.S. access to and the free use of the space domain in peace and in war. DOD and Congressional support for counterspace weapons are vital to align resources, engage the scientific and development communities, and mobilize the industrial base to achieve the future force design.

Space Warfighting Analysis Center (SWAC)

SWAC is a direct reporting unit of the USSF that develops future force design options for the Chief of Space Operations. The SWAC is headquartered in Colorado Springs, CO, and was founded in 2021, building on the previous efforts of the Enterprise Strategy and Architectures Office and the Space Security and Defense Program to provide the Space Force with a consolidated organization for architecture and force design.

Source: See CSO Planning Guidance.

Space Force Acquisition Organizations

Space Systems Command (SSC)

SSC is responsible for developing, acquiring, equipping, fielding, and sustaining space capabilities for warfighters. The command conducts launch operations, on-orbit checkout, developmental testing, sustainment and maintenance of military satellite constellations, and other Department of Defense space systems. With 19 operating locations and over 15,000 military, civilian, and contractor personnel, SSC activities range from small scientific experiments to large national security missions like AEHF, GPS, and SBIRS. SSC, headquartered in Los Angeles, CA, is one of three Field Commands within the USSF. While it stood up in 2021, SSC traces its heritage to the ICBM and rocket development efforts led by General Bernard Schriever in the 1950s and 60s and the Space and Missile Systems Center.

Space Rapid Capabilities Office (Space RCO)

The Space RCO mission is to develop and deliver operationally dominant space capabilities at the speed of warfighting relevance. The Space RCO expedites delivery and deployment of space capabilities in response to the requirements of the commander of U.S. Space Command. Space RCO is a small, streamlined organization enabling the rapid response required for unique missions. The Space RCO was established in 2018 and is headquartered at Kirtland AFB in Albuquerque, NM.

Space Development Agency (SDA)

The agency will quickly deliver needed space-based capabilities to the joint warfighter to support terrestrial missions by developing, fielding, and operating the Proliferated Warfighter Space Architecture. The Space Development Agency capitalizes on a unique business model that values speed and lowers costs by harnessing commercial development to achieve a proliferated architecture and enhance resilience. It will deliver a minimum viable product on time every two years by employing spiral development methods, adding capabilities to future generations as the threat evolves. The agency was founded in 2019 and is headquartered in the Pentagon.

Sources: U.S. Space Force: Space Systems Command; SSC 2023; Space RCO; Space Development Agency.

Develop a Comprehensive Counterspace Force Design

With an adjusted national policy and clear direction, the Space Force can begin to develop a complete and cohesive architecture that will assure U.S. freedom of operations in space. The Space Warfighting Analysis Center (SWAC) should conduct an accelerated assessment to define a robust force design capable of deterring and, if necessary, defeating Chinese aggression in space. This force design should have an architecture that will give theater commanders reversible and irreversible options to conduct both terrestrial-based and space-based defensive and offensive operations that will not create long-lived debris in space. Additionally, this force design must be informed by a combination of threat assessments, operational objectives, current and emerging technologies, and existing capabilities.

Develop and Field an Architecture for Responsible Deterrence and Defense in Space

The Space Force must begin to acquire counterspace capabilities in earnest. This should start with Research and Development (R&D) investments to develop technologies that transition to the production of systems. As the Space Development Agency continues to increase the Space Force's resilience through proliferation, the Space Rapid Capabilities Office (Space RCO) and Space Systems Command (SSC) should concentrate on acquiring counterspace capabilities. Consistent with the SWAC's recommended force design, these capabilities should include separate ground-, air-, sea-, and space-based counterspace systems, as well as satellites with integral defensive systems to assure their ability to perform their primary missions.

The Space Force has multiple options for developing counterspace capabilities that are consistent with the "no-debris" imperative. For example, France, which has also prohibited its military from developing space weapons that create dangerous debris, has officially announced it is developing a satellite with a laser to patrol GEO and defend its satellites.[70] A main benefit of a space-based laser weapon is that it can effectively disrupt, degrade, or even disable a target threat without generating debris. An additional benefit of a laser is its ability to recharge and engage multiple threats without the need to reload kinetic elements like expendable projectiles, which is a much more challenging problem in space than on Earth. This increases the flexibility and utility of a laser as a defensive system. Other systems, such as electronic warfare (EW), cyber weapons, or high-powered microwaves (HPM), could also be part of a credible and responsible deterrence force in space.

There are three critical capability areas the Space Force must focus on in parallel to create a space architecture that provides effective and responsible counterspace options to theater commanders: defensive space capabilities, offensive space capabilities, and the required infrastructure to inform and execute counterspace operations at scale. These elements would work in conjunction with one another to produce the most effective and credible means of deterrence.

Figure 5: Pacific Island chains Source: Mitchell Institute

Defensive Counterspace Capabilities to Protect Vital U.S. Space Assets

U.S. space systems require a suite of defensive countermeasures to improve their overall level of mission assurance beyond what is possible through resilience or reconstitution measures alone. This means new capabilities are needed that go beyond current efforts to improve satellite hardening and jam-resistance of a select few satellites. These could include attack avoidance capabilities, like increasing the maneuverability of satellites by equipping them with larger propellant tanks; capabilities to refuel while in orbit; or alternative, more efficient propulsion systems. With greater propulsive capability, Space Force satellites could avoid incoming threats and, more importantly,

frequently maneuver prior to attacks, thus preventing adversary counterspace systems from effectively targeting them in the first place. The Space Force should also pursue more direct countermeasures, like lasers that can blind or confuse the sensors of adversary threat systems. This would be like equipping aircraft with flares that pilots can expend to divert heat-seeking missile threats. This would finally give U.S. satellite operators options to exercise the inherent right of self-defense.[71]

Defensive countermeasures do not have to reside on currently fielded or future high-value space assets. The Space Force could develop separate "bodyguard" satellites with a suite of measures to assure vital space systems have continued freedom of operations. Certain ground-based options may also prove effective at countering space threats. Again, analysis will be critical in determining the best set of options for fielding. Whether defensive countermeasures are onboard, separate, or even terrestrial, they must address the full spectrum of space threats. Where possible, countermeasures should try to defeat multiple threat types or categories of threats, such as co-orbital threats. Defending against a co-orbital threat by disabling the attacking satellite itself might be possible, whether the aggressor satellite has EW, laser, robotic arm, or HPM weapons. Still, no single countermeasure will be effective against all threats, which is why the Space Force must build a defensive architecture with a diverse mix of capabilities to defeat different attack vectors.

Offensive Counterspace Capabilities to Defend Against Space-Enabled Attacks

Even if all Space Force mission assurance activities succeed and preserve U.S. space capabilities in a conflict, fighting to simply maintain equivalency with the adversary is not a war-winning approach and undercuts the deterrent posture of the United States. There is an increasing necessity for U.S. offensive capabilities to be able to counter China's expanding use of space to increase the effectiveness of its own air, sea, and ground operations. These capabilities should span the response spectrum, from giving senior leaders options for "responding in kind" as a punitive answer to Chinese ASAT attacks to fielding capabilities for large-scale operations to defend U.S. Soldiers, Sailors, Marines, and Airmen from Chinese space-enabled attacks.

The Law of Armed Conflict

The Law of Armed Conflict (LOAC) provides guiding principles to minimize human suffering in war and applies to conflict extending to space. Two fundamental principles, military necessity and proportionality, are particularly relevant when considering warfare extending to space. Military necessity establishes that warfare aims to weaken the enemy's military forces. This justifies actions that achieve this objective as long as they comply with the other principles. Similarly, proportionality attempts to limit collateral damage by prohibiting the use of excessive force. The force applied to attack a target must be proportional to the military advantage gained by attacking that target. Underpinning all the principles of the LOAC is the belief in reciprocity—each side in a conflict will respond in similarly.

Source: "The Law of Armed Conflict: Basic Knowledge," International Committee of the Red Cross, June 2002.

Priorities for a Large-Scale Conflict with China

U.S. combatant commanders should have a wide range of options for offensive counterspace operations to defeat space-enabled attacks in the event of a major conflict with China. One option that would likely have an immediate effect is countering the space-based ISR systems China depends on to track and target U.S. and allied forces heading to or operating within the Pacific's first and second island chains (see Figure 5). Space Force counterspace systems could help defend the lives of U.S. and allied personnel by either temporarily or permanently disabling China's collection or transmission of ISR information over long ranges from and through space.

Next on the priority list would be delaying, degrading, and potentially denying the ability of Chinese forces to communicate with one another. This would make Chinese military operations less synchronized and effective. The Space Force could offer ground-based capabilities like CCS to achieve this but would require these satellite communications jammers to deploy close to areas a theater commander wants to target. This would be extremely challenging given the highly contested nature of the battlespace, defended by China's anti-access and area denial (A2/AD) threats. Space-based solutions offer a far better solution. The same holds true for disrupting China's PNT capability. Disrupting PNT would decrease the PLA's ability to coordinate large-scale military maneuvers over large areas of the battlespace, and it would decrease the effectiveness of their satellite-guided munitions. While this priority of counterspace activities is proposed for China, it applies to any potential adversary using space to threaten U.S. interests.

Offensive Space Operations Should Be Responsible

Of note, U.S. offensive space operations should be calibrated to achieve finite, specific effects on adversaries' militaries and their warfighting operations. Like the United States, some of China's space systems are designed for military and civilian applications. For instance, the temporary, localized disruption of the PLA's PNT would, in most cases, be a better option than wholesale attacks on China's space-based PNT architecture. Targeting the entirety of China's PNT space constellation would have global ramifications, as would large-scale attacks on the U.S. GPS constellation—both are used globally for non-military purposes. Similarly, neither side should attack the other's nuclear missile launch detection and early warning space systems. Attacks on these systems would be highly destabilizing and could increase the potential that a conflict would rapidly escalate to levels that are in no one's interest. These and other limiting factors should guide the development of the Space Force counterspace force design and inform the development of future norms of responsible behavior or treaties for the space domain.

Improve the Space Infrastructure Enabling Effective Counterspace Operations

A complete Space Force counterspace posture requires more than weapon systems. The need to know where to employ those weapons and the ability to assuredly command and control them is key. Additionally, the Space Force must test these systems and have trained personnel to develop and operate them. Improvements in Space Force SDA, satellite operations, training, and testing will be essential elements of the counterspace force design. There are already Space Force initiatives underway to improve each of these, but to possess the precision, speed, and certainty needed to execute effective counterspace operations at scale against a peer adversary will require even greater effort and support moving forward.

Improve Space Domain Awareness

For the Space Force to know where and when to engage both defensive and offensive counterspace systems, it will require significant improvements in space domain awareness. It may seem obvious, but a system or action can only be understood as a threat given enough situational awareness. The legacy space surveillance architecture lacks the fidelity required to understand dynamic developments on orbit, especially with a hostile adversary seeking to avoid attribution. To provide the level of awareness necessary to inform defensive and offensive counterspace operations, the Space Force must increase the size of its space intelligence forces. Robust space intelligence forces will better inform U.S. capability development, track fielded Chinese and Russian systems, and ascertain opportunities to exploit potential adversary vulnerabilities. The Space Force must also field additional SDA sensors to fill existing gaps in coverage, better maintain custody of ASATs, provide alerts when ASATs engage U.S. and allied systems, and inform U.S. counterspace operations. Where the adversary goes, U.S. sensors must already be there. This is why additional efforts to monitor the cislunar region of space, which China or Russia could use to create unwarned attack vectors, are vital. Moreover, placing localized sensors around U.S. high-value space assets will provide an additional element of security and awareness. Space domain awareness must also include the identification and characterization of threats to space interests, whether those threats exist in space, in the air, on land, or at sea. Finally, all SDA data must be accessible via high-speed network to enable the application of artificial intelligence and machine learning algorithms to detect patterns of behavior, provide timely warning of potential attacks, and identify viable courses of action.

Improve Satellites TT&C and Satellite Control Network

To meet the requirements of a highly dynamic warfighting domain, the Space Force must change how it commands and controls its satellites. The Space Force can no longer afford the luxury of prolonged gaps between contacts with satellites if it is to effectively detect and counter adversary attacks. Reducing these gaps in time will require a TT&C system with constant connectivity or at least the capacity to contact all Space Force satellites simultaneously. This will ensure the continued delivery of space services and enable appropriate responses, like maneuvering satellites to avoid threats or deploying countermeasures. Space Force weapon systems in orbit will also require positive control and an elevated level of surety to prevent the unauthorized use or tampering of counterspace weapon systems. The Space Force's future TT&C must also provide a guaranteed and secure means to communicate between satellites and their ground operators or users. The links between these elements must withstand adversary jamming, cyber intrusion, and other attacks.

Enhance Guardian Training and Testing to Excel in a Warfighting Domain

A weapon system is only as good as the personnel operating it, and operators are only as good as their training. The Space Force's Space Training and Readiness Command (STARCOM) is already pursuing improvements in training Guardians to adapt to space as a warfighting domain, but this training currently reflects the Space Force's lack of counterspace capabilities.[72] As the Space Force grows its counterspace capabilities, it will need to expand the scale and scope of its training. No longer will it be sufficient to be a skilled technical operator focused on simply delivering a service. Guardians must now think in tactical, operational, and strategic applications—understanding the technologies and how to employ them in a dynamic military context or under threat.

New counterspace systems will require new training pipelines and recurring proficiency training. Additional training capacity to address both China's and Russia's counterspace systems must be available to all Guardians, not just those operating counterspace systems. This training must go beyond simple classroom training. Hybrid-live and virtual training would enable the Space Force to include counterspace capabilities into its exercises and wargames without impairing the space domain or unintentionally divulging Space Force capabilities or limitations. This will advance Guardian development of counterspace tactics, techniques, and procedures.

STARCOM is already building leading elements of this infrastructure in the National Space Test and Training Complex (NSTTC).[73] As the name implies, the National Space Test and Training Complex will provide an essential test environment for the Space Force. New Space Force systems, especially weapon systems, require extensive testing before fielding. By leveraging the virtual and digital elements of the NSTTC, the Space Force can safely and securely test and evaluate the effectiveness and suitability of defensive and offensive counterspace systems. Fully funding this effort and its infrastructure, and ensuring it possesses the necessary counterspace capabilities, is essential to preparing the Space Force to confront Chinese aggression in space.[74]

Grow the Guardian Workforce

The Space Force will need more personnel and funding to change its force design and develop, procure, test, and field counterspace capabilities. The Space Force's budget has steadily increased since its inception, in a combination of absorbing pre-existing missions from other services and real growth. However, there will need to be a surge of support to build a more complete and robust force design that includes new counterspace forces. Existing missions have already stretched Space Force acquisition, training, and operations to the breaking point. Where the Space Force needs to go represents a step function increase in mission demand growth—resources need to align.

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Adding counterspace capabilities to the mix will naturally require more Space Force personnel and workspaces. This more specifically includes additional acquisition professionals in SSC and the Space RCO to procure and integrate counterspace systems. It also requires additional space intelligence professionals to inform acquisition and operation decisions, as well as additional space and cyber operators—potentially in new operational squadrons—to operate the service's expanded architecture. STARCOM will furthermore need additional instructors, both to train Guardians on the new systems and to provide more comprehensive training for all to respond to Chinese threats. Finally, Space Force leadership and staff elements must have the capacity to provide guidance and oversight over a growing

force. In total, needed growth will drive the Space Force beyond its current projected end strength of 18,000 military and civilian personnel. The growth in personnel will drive a need for more facilities. The Space Force will likely require military construction to support this essential growth with research facilities, acquisition offices, and operational centers.

Explore and Debate Space Weapons for Terrestrial Targets as a Hedge Against Escalation

Senior U.S. civilian and military leaders must decide which path to take regarding space weapons that can engage terrestrial targets. The immediate priority for the DOD is to develop and field Space Force defensive and offensive counterspace capabilities and supporting infrastructure with the capacity to deter and, if necessary, defeat adversary aggression in space. However, the DOD must be prepared to pursue options to strike ground, naval, and air forces from space as a next step. As more U.S. kill chain functions—find, fix, track, target, engage targets, and assess—move to space in response to China's expanding A2/AD threats, it will become necessary to develop weapons that can engage a range of targets from space. Like counterspace operations, these cross-domain engagements could use a variety of non-kinetic and kinetic capabilities that can create reversible to irreversible effects. DOD will have to resource science and technology initiatives to explore concepts for these weapons in order for future decision-makers to have them as an option. Without exploring technologies and policies for their use today, DOD will simply not have the option of acquiring them in the future. Alternatively, the issue of deploying weapons in space to attack airborne, ground-based, and maritime targets is fertile ground for international discussions over their limitations. Agreeing to prohibit these weapons would only be advisable if the countries like China and Russia agree and adhere to new standards, the United States has reliable means to verify compliance, and there are clear consequences for violations. There are pros and cons to both paths, but unless the United States proactively makes a decision, it risks deferring the decision to China, Russia, or another potential adversary.

Additional Considerations to Shape Space Force Counterspace Capabilities

Centralize Development of Counterspace Forces to Avoid Unnecessary Duplication

To be fiscally responsible as well as operationally efficient, there must be clear DOD direction from the beginning on the Space Force's responsibility and authority to lead the development of a joint counterspace force design. Having a single joint counterspace force design is essential to provide the Space Force and other services with a clear roadmap for the future, avoid unnecessary duplication of effort, and align future activities and resources across DOD. The counterspace force design should be a Space Force document endorsed by the Secretary of Defense that includes and informs the efforts of the other military services and the Intelligence Community.

The United States consolidated a substantial portion of DOD's military service space activities when it created the Space Force, but unless DOD policy better clarifies service responsibilities, it is probable that each service will independently pursue its own counterspace systems. This is analogous to how the Navy, Army, and Marine Corps all retained fixed-wing aircraft for missions such as fleet defense and close air support even after the establishment of the Air Force as a separate service in 1947, or how the Air Force, Navy, and

Army all developed ballistic missile systems in the 1950s. Each of these examples resulted in the fielding of operationally relevant capabilities, but there was also considerable redundancy and little collaboration among the services as they were developed. In the age of jointness and budget efficiencies, the DOD must do better with the development of counterspace forces and capabilities than it did in these historical examples.

Avoid Classification Issues That Can Impede Deterrence

There are three major classification considerations for the Space Force's counterspace force design. First, the Space Force should make the fact of this architecture's existence and its broad characteristics public knowledge to ensure it has the maximum deterrent value. However, like all weapon systems, the Space Force must protect critical details about its new counterspace capabilities and their limitations in order to prevent or delay adversary development of countermeasures.

Second, the counterspace force design must be accessible to the necessary personnel and avoid the classification trap of only being available to a handful of users. To ensure unity of effort, a version of the force design must also be accessible to a broader audience of U.S. policymakers, members of Congress, the DOD, industry, allies, and even academic institutions who are tasked to conduct research to support the architecture's development. Further, an accessible counterspace force design enables combatant commands to exercise and integrate those capabilities into their plans. Ideally, the Space Force's counterspace force design would be explained in an unclassified plan, like other services' strategic roadmaps or the Congressionally directed unclassified strategy to protect and defend investments in space.[75]

Finally, for those areas which must remain classified, the Space Force and defense industry will require more billets and cleared facilities to plan, develop, test, field, and integrate capabilities. These personnel and facilities will also require appropriate network access for classified information processing. While still maintaining the standards to access classified information, the expansion of the number of people and organizations with clearances will increase the speed and diversity of options and solutions.

Partner With Industry

The development and fielding of counterspace capabilities will require the Space Force to maintain a strong partnership with the defense industry. Ideally, the Space Force and industry will partner to define the art of the possible, build from lessons learned from programs that operate in other domains, and jointly define a counterspace force design and subsequent architecture. There is a wealth of information available to the Space Force from traditional and non-traditional industry partners. By exploiting technologies developed and lessons learned from industry's independent research and development efforts and experiences in related fields, the Space Force can accelerate its own efforts. At a minimum, industry must rapidly respond to the demand signals coming from the Space Force and develop capabilities that are needed to deter China this decade.

Recommendations and Conclusions

The United States recognizes that the preservation of its access to and use of the space domain is a vital national interest. Space capabilities and the effects they provide are essential to every aspect of modern life, and they are indispensable force enablers and multipliers the U.S. military depends on to deter and defeat threats to the United States. The nation's recognition of this criticality was part of the reason for establishing the U.S. Space Force as a separate service. The Space Force must now organize, train, and equip combat-ready forces to continue to provide these essential effects and to protect them from the mounting threat of attacks by a peer adversary.

China is the pacing threat for developing the Space Force's future force design. While China is the most challenging threat, they are not alone. Many nations have observed the incredible advantages space capabilities have provided the United States and its military forces during multiple regional conflicts over the past 30 years. As a result, China and others have made two critical decisions. First, they have decided that space is a key vulnerability of the U.S. military and are developing weapons to threaten its access to and use of space. China, in particular, has already fielded multiple systems explicitly aimed at attacking U.S. space capabilities. Second, nations around the world are seeking to leverage space capabilities for commercial, civil, and military purposes. Again, China is leading the way with a rapidly expanding use of space to enhance its military. This means American Soldiers, Sailors, Airmen, Marines, and Guardians will be in the crosshairs of space-enabled attacks in a future conflict.

The United States must deter adversaries from attacking its space systems, whether they misguidedly attempt to prevent the United States from responding to a crisis or launch an initial salvo of a major conflict. China believes an "awe-inspiring" attack against U.S. space capabilities and forces would be an effective deterrent measure against the United States. International norms and increased resiliency are necessary but alone not sufficient to deter such an attack. As more nations, organizations, and companies become spacefaring, the need to develop standards of conduct to preserve access to the space domain for all increases. This includes prohibitions against creating long-lived debris and other norms that are essential for safe operations in an increasingly congested domain. However, these norms will not deter China's continued development of space weapons, nor will they deliver the means to defeat Chinese space attacks. The same is true for increasing resiliency. A U.S. space architecture that is more resilient could diminish the effectiveness of Chinese attacks, but given China's perspective on deterrence and the role space plays in modern military operations, a resiliency-only approach will be insufficient.

For a more complete approach, the Space Force should develop defensive and offensive counterspace capabilities and support elements that can protect U.S. national interests in space and hold adversary space assets at risk. Concerted Space Force and industry efforts to develop, field, and operate a range of counterspace capabilities will simultaneously increase deterrence and provide the means necessary for U.S. combatant commanders to defeat aggression should deterrence fail. The following recommendations outline the steps the U.S. administration, Congress, industry, and the Space Force should take to develop these essential counterspace capabilities and their supporting infrastructure:

- **Senior U.S. civilian and military leadership should explicitly and publicly state the need to field counterspace systems**. Clear guidance is essential to deter potential adversaries and align the resources necessary to field the required counterspace capabilities. Continued silence on the issue will risk further emboldening adversaries.

- **The Space Warfighting and Analysis Center should develop a jointly informed and accessible counterspace force design**. This will require a detailed analysis of threats, current and emerging technologies, and the effectiveness and limitations of potential capabilities. Existing systems developed by the other services should also inform this force design to help prevent unnecessary duplication of effort. The force design must guide activities across the entire DOD in support of the counterspace mission.

- **SSC and the Space RCO should partner with industry to develop the necessary defensive and offensive capabilities**. These capabilities should include both onboard and off-board defensive measures for high-value satellites. Offensive counterspace systems must be consistent with the principles of the Law of Armed Conflict and will clearly be required to defend joint and combined operations from adversary space-enabled attacks in future crises and conflicts.

- **The defense industry must respond quickly to USSF requirements and requests for information**. Given the decades of relative neglect in the area of space weapons, the Space Force will need to be able to leverage technologies and lessons learned from industry and other domain acquisition programs in order to accelerate counterspace weapons development.

- **The Space Force must improve its space domain awareness capabilities** to enable effective defensive and offensive counterspace operations. This includes growth in sensors and processing capabilities to enable tracking and warning of threats and a more enhanced SDA architecture capable of faster processing of collections and observations around high-value assets—and in key regions like GEO and cislunar.

- **The Space Force must improve its satellite TT&C capabilities.** This is essential to rapidly respond to threats and maintain positive control over its space weapon systems. The Space Force will need a higher-capacity TT&C architecture capable of maintaining contact with its current and future systems, including space weapons.

- **The Space Force must improve its testing and training architecture.** Additional live, virtual, and digital elements in the National Space Test and Training Complex are required for Guardians to evaluate new counterspace systems and train all operators for the reality that space is a warfighting domain.

- **Congress must authorize and fund additional Space Force growth.** Increases to the Space Force's civilian and military personnel and the construction of additional facilities are needed for counterspace systems. Establishing the counterspace mission as a central task for the Space Force will create a requirement for growth beyond the originally anticipated force size of 18,000 personnel.

The criticality of space to U.S. national interests and the mounting threat to those interests are clear. The United States must employ a full array of methods to deter this aggression, preserve stability, and assure its access to and use of space. A war that extends to or starts in space is in no one's interest. The United States is actively pursuing means of preventing such a conflict. A strong Space Force both aids the U.S. deterrent stance and provides integral war-winning capability should deterrence fail. Norms of responsible behavior, improved resilience, and expanded space domain awareness are all vital elements of a comprehensive strategy but by themselves will not achieve all U.S. national security objectives. To credibly deter and, if necessary, defeat an adversary like China, the Space Force must have a robust suite of counterspace capabilities to protect national interests in space and defend fielded forces from an adversary's space-enabled attacks. Corresponding growth in personnel and resources and a clear articulation of guidance are required to ensure those counterspace capabilities have the capacity and effectiveness to be credible. ✪

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