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Key Points

Space superiority is foundational for operational success in all domains, every service, and in each combatant command, but U.S. space superiority is no longer guaranteed.

China and Russia are fielding increasingly capable counterspace threats against every segment of space systems—orbital, terrestrial, and link—to contest U.S. military and civil space operations. Addressing these threats requires defensive and offensive counterspace options from all domains—air, land, sea, cyber and space.

All military services must support U.S. Space Command in gaining and maintaining space superiority.

The prevailing and historic mindset in the Department of Defense is that space is a supporting domain. This must change to reflect the new reality–operations in all domains are needed to support space operations.

Supporting U.S. Space Command to achieve space superiority through cross-domain operations demands transformation across four lines of effort: clarifying roles and missions, investing in technology, enhancing education, and training to new contested space scenarios in major theater exercises before conflict arises.

Charting a Path to Space Superiority: The Cross-Domain Imperative

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Abstract

Space superiority is an essential U.S. national security imperative, as it underpins all U.S. military operations as well as key civil and commercial services. As China and Russia field increasingly potent space capabilities and counterspace weapons that threaten the U.S. space architecture in orbit and via its terrestrial components, all warfighters in all domains must prioritize achieving space superiority as a foundational condition for conducting successful operations.

First and foremost, the Department of Defense (DoD) must conduct a comprehensive review of space roles and missions across the national security enterprise to clarify institutional responsibilities. Next, the DoD must prioritize cross-domain capability investments to improve the survivability of the space architecture and provide operators more flexible options. The next step in achieving a new space superiority construct involves changing the culture—to treat space as a true warfighting domain. The DoD must educate its warfighters about the scale and scope of the threat, help them understand space dependencies, and then focus on the multidomain training necessary to prevail in contested space scenarios. Deliberately employing contested space scenarios in major theater exercises must occur before conflict in space erupts—the United States cannot face these challenges for the first time with real lives at stake. Without these urgent reforms, space superiority will remain aspirational, and the United States risks defeat in this linchpin domain.

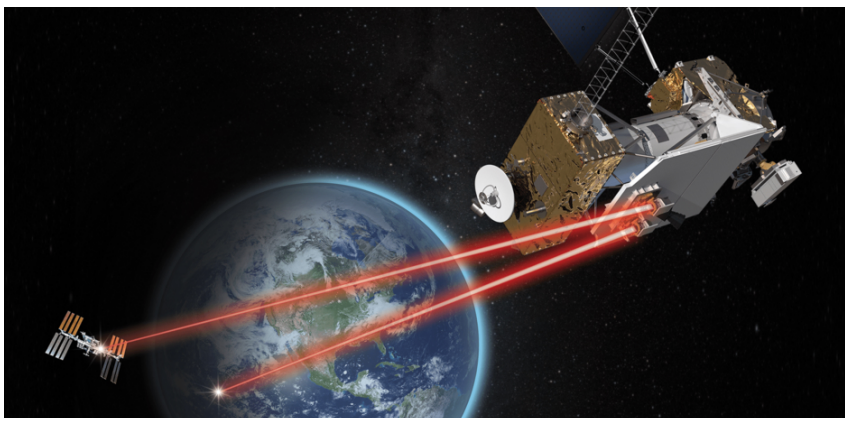

Figure 1: NASA's Laser Communications Relay Demonstration (LCRD) has conducted successful experiments in geosynchronous orbits. Credit: NASA graphic

Introduction

America's security and prosperity increasingly depend on space. Systems on orbit underpin all foundational military operations, from intelligence, signals and warning, navigation and precision strike to global communications. Banking, logistics, and disaster response also depend on space-based capabilities. For decades, space has been a relatively uncontested domain. That era is over. Adversaries are fielding and exercising capabilities that continue to intensify competition and increase the risk of conflict—both on Earth and in space.

China and Russia's counterspace capabilities threaten all elements of the U.S. space architecture: the satellites in orbit, the ground stations that control them, and the links that connect the two. Critically, they are doing so while designing their own attack-resilient space systems that are integrated across their military forces.

While most senior U.S. leaders and Guardians understand the realities of a contested space domain, others in the military and the broader security community have been slow to recognize the scale, scope, and multi-domain implications of these challenges. The new reality in space is not just a concern for the U.S. Space Force or U.S. Space Command. It demands attention from the entire Department of Defense (DoD). Space superiority is now a dynamic objective that must be actively gained, maintained, and—if lost—regained. That takes an all-domain total team effort.

Adversary threats to U.S. assets on orbit and U.S. defensive measures of them are not restricted to space. Consider an enemy's anti-satellite missile launched from a ship or a ground installation. Space Command may need an Air Force B-21 to strike the launch source. Similarly, an Army air and missile defense unit may need to protect a terrestrial downlink station from enemy attack from the air. These examples are merely the tip of the iceberg when it comes to multi-domain collaborative actions to defend America's spacepower enterprise. This teamed approach permeates every warfighting domain—air, land, sea, cyber, and space. Therefore, training, practices, equipment, and organizational responsibilities must reflect this across the DoD and within the individual services.

Understanding Space Superiority

Space superiority is a degree of control that allows forces to operate at a time and place of their choosing without prohibitive interference from space or counterspace threats while also denying the same to an adversary.

Source: *Military Space Operations Terms of Reference*, September 2024, paragraph 3.1.

Space has often been excluded from the broader discussion of cross-domain warfare, even though its effects span every component of the force. While the U.S. military has made significant strides in recognizing space as a warfighting domain, most of that effort remains contained to the U.S. Space Force and U.S. Space Command. Defense-wide operational practices remain rooted in the premise that space is a permissive environment. This assumption perpetuates the treatment of space capabilities as supporting functions for terrestrial purposes that can be taken for granted. The truth is that space is a distinct domain involving a variety of mission functions where superiority must be proactively earned if warfighters in all domains expect it to deliver effects.

Securing space superiority is a joint and combined imperative that will require fundamental shifts in institutional priorities across the national security enterprise, training, and even basic mindsets. It will also require new capabilities and operational concepts. The DoD must proceed with four interdependent lines of effort to ensure its access to space effects:

1. **Review and define clear roles and missions** to eliminate duplication, resolve seams, direct responsibilities, and coordinate action
2. **Increase technology investments** that close operational gaps and integrate cross-domain effects
3. **Improve education** to create a shared understanding of space operations across the services
4. **Conduct exercises** that allow joint and allied forces to rehearse gaining and maintaining space superiority as the goal and in the context of other, theater-focused objectives.

The DOD must align all the military services, combatant commands, and other space warfighting agencies to secure space superiority in this contested era. Failure to do so places America's security and prosperity at risk.

The Evolution of Space: Tracking Toward a New Warfighting Domain

Without assured spacepower, terrestrial warfighting would look like the horrors of World Wars I and II and could very well end in defeat if our adversaries retained their space capabilities. Forces would lack necessary situational awareness, connectivity, command and control, weather intelligence, plus indications and warnings. At the same time, in the face of growing threats to space, U.S. SPACECOM can no longer remain just a supporting command focused solely on enabling operations in other domains. It needs the support of other combatant commands as it fights to gain and maintain space superiority.

To better understand how SPACECOM can now be a supported command, it is important to understand the three distinct space "ages" that characterize the development of space operations, the threats those operations face, and the U.S. military's approaches and organizational constructs to address them.

Understanding the Difference Between Supported & Supporting Commanders

A supported combatant commander has the primary responsibility for all aspects of a task assigned by Contingency Planning Guidance, the Joint Strategic Campaign Plan (JSCP), or other joint planning directives.

A supporting combatant commander provides forces, assistance, or other resources to a supported commander in accordance with the principles set forth in DOD's Global Force Management policies and procedures.

Source: Joint Publication 5-0, Joint Planning

The First Space Age (1957–1990s): Space for Strategic Effects

The First Space Age marked the initiation of space operations, during which U.S. capabilities on orbit enjoyed a generally uncontested operational environment. As such, the systems were built with little thought for defensive or protective technology. The peaceful race to the moon epitomized the civil space enterprise of the time. Commercial space remained limited to a handful of communications satellites due to the difficulty and expense of building, launching, and operating space-based assets.[1]

The Cold War competition between the United States and the Soviet Union characterized this era. Space activities for both nations focused primarily on fielding strategic military systems and prestige civil science efforts. These included missile warning, nuclear command and control, environmental intelligence, and space-based intelligence, surveillance and reconnaissance (ISR) capabilities.[2] Although the United States and the Soviet Union both researched and developed the first anti-satellite weapons (ASATs) during this time, neither nation operationalized these weapons. Space-based assets were critical to maintaining nuclear stability, which meant

that the weaponization of space presented an outsized risk to that stability.[3] As such, that risk was never realized in this era.

The Second Space Age (1990s–2000s): Operationalization of Space

The permissive nature of the space domain persisted in the Second Space Age. The absence of threats to the domain, combined with the cost and difficulty of accessing space, drove nations to develop exquisite, but ultimately vulnerable, capabilities. Every pound of a satellite was engineered toward functionality with no consideration toward defense. This model was sustainable because the United States enjoyed uncontested access to and operations in any orbit.

The integration of space effects with terrestrial military operations expanded rapidly in this era. In the 1990s, the first Gulf War provided proof positive of how these space capabilities could be used to contribute to a decisive victory:

- **Space-based imaging** assisted with targeting for precision-guided weapons.
- **Early positioning, navigation, and timing applications** guided some force maneuvers.
- Space-based environmental monitoring forecasted the effects of weather on operations.
- **Space-enabled communications** began to link warfighters at the tactical, operational, and command levels.
- **Space-based tactical missile warning** provided life-saving situational awareness in operations that extended to conventional strike launches, not just nuclear strikes.

By the end of the Second Space Age, the effects delivered via spacepower were no longer merely an added benefit; they became critical. Space capabilities were generally integrated as a supporting function of all U.S. military operations.[4]

Space Is Integrated in Daily Life

GPS is one of the most widely proliferated space products available. Not only do consumers around the world use GPS-supported maps on their cell phones for personal navigation, but gas stations, automated teller machines, Wall Street, the banking industry, rail, air traffic control, power grids, and even terrestrial communications systems use GPS timing signals—it has become a public utility. Other proliferated space capabilities include long-haul and personal communications, weather and climate forecasting, crop forecasting, and myriad imaging applications. The ubiquity of space applications throughout modern life makes the defense of all space assets challenging. Operations across all domains are needed to ensure freedom of action in space for all users.

At this time, the U.S. military expanded its use of space capabilities beyond defense-specific space systems to include commercial space systems, like the PanAmSat commercial satellite communications systems and the Direct Broadcast Satellite (which also provided the original and widely proliferated DirecTV feed). Civil consumers also increasingly relied on military and commercial space applications, like the global positioning system (GPS).

The Third Space Age (2007–Present): Space Domain Under Threat

The Third Space Age began to emerge in the early 2000s, when China developed counterspace capabilities to challenge U.S. space dominance. The tipping point occurred in 2007, when China demonstrated its ability and willingness to destroy a satellite in orbit. This was a game-changing moment, and it fundamentally altered the dynamics of spacepower. Space became a warfighting domain. The significance of this change from benign to contested means that space superiority must now be achieved just like superiority in every other warfighting domain.

China's successful 2007 launch of a ground-based, direct-ascent anti-satellite weapon to intercept a defunct Chinese weather satellite in orbit was just the beginning. China not only desired to further develop these capabilities, but it also has the resolve to use them. While the Soviet Union and United States had tested ASATs during the Cold War, their provocative nature and the risk they posed to the domain in terms of orbital debris and nuclear stability drove both countries to abandon their programs by the late 1980s.[5] China continues to develop a broad range of offensive space systems today.[6] Moreover, China's kinetic strike in 2007 created thousands of pieces of debris that remain a persistent risk to manned and unmanned space vehicles.

Russia reportedly possesses similar counterspace capabilities to China. They continue to test on-orbit nuclear capabilities and invest in disruptive and destructive space capabilities aimed at offsetting perceived U.S. advantages. Additionally, the risk exists for additional anti-space technology proliferation through Russia's military sales.[7]

Meanwhile, both the U.S. military and the nation's civilian sector have become more reliant on space-based capabilities by the day, and the existing DoD space architecture assumes peaceful conditions on orbit. Adversaries big and small are keenly aware that the loss or even degradation of space operations could have potentially catastrophic consequences for the United States in both military and economic dimensions. America will always rely on space-based capabilities, so it is essential that the U.S. military be able to secure access to its on-orbit assets.

At the same time, China recognizes the value space presents to support its own military and civil sectors. It is also growing increasingly reliant on this domain. Recent organizational reforms within the People's Liberation Army (PLA) reflect that China understands its space assets must be defended and adversary assets neutralized.[8] In 2015, the PLA stood up its Strategic Support Force with a specific focus on space operations. In 2024, the PLA restructured for even greater emphasis on space with the addition of its Aerospace Force.[9] If China is preparing to fight and win in space, so too must the United States.

Accordingly, the United States formally acknowledged space as a warfighting domain in 2019 by establishing U.S. Space Command as a geographic combatant command. The Trump administration and Congress also created the U.S. Space Force as a military service equal to the other service branches. The purpose of these organizations is to gain and maintain space domain superiority—just as the terrestrial services do in the domains of air, sea, and land.[10] And, just as the terrestrial forces depend on cross-domain support to be successful (e.g. close air support to the Army from the Air Force), the Space Force requires the terrestrial services and combatant commands provide combat support to the space domain. Terrestrial services and commands have never had to consider this requirement in past eras; now, it is an imperative.

Understanding the Current Space Threat Environment

Any spacepower threat assessment must begin with a clear-eyed acceptance of the facts that, today, no orbital regime is entirely safe from PLA attack. Chinese forces can use their maturing on-orbit capabilities to track and target U.S. forces in other warfighting domains. Finally, China's actions over the past two decades demonstrate its lack of compunction to wield its space-based and counterspace capabilities against those who would attempt to interfere with their military operations.

China recently fielded a proliferated architecture of over 200 ISR satellites to enable attacks across the Western Pacific and beyond.[11] According to Lt Gen Gregory Gagnon, former Deputy Chief of Space Operations for Intelligence, this network is purpose-built to be resilient against attack: it is "an architecture that is designed to go to war and sustain a war."[12] China can use these assets to close its own air-to-air, air-to-surface, and surface-to-surface long-range kill chains in support of its Anti-Access Area Denial (A2AD) operations. China is also fostering partnerships with Argentina, Pakistan, Kenya, Sweden, Australia, and other states to support launch and satellite tracking and telemetry to fill geographic gaps in its space domain awareness network.[13] This means China's command and control of its space assets is highly optimized for global operations and not just regional operations, as in the past.[14] As China continues to field increasingly capable long-range strike weapons like the DF-21D anti-ship ballistic missile, its space-enabled kill chains will allow it to keep its own forces further out of reach of U.S. counterstrikes.[15]

At the same time, the PLA understands the U.S. reliance on space and seeks to deny, degrade, and destroy this lever of power. It has modernized and expanded their forces to specifically counter U.S. warfighting capabilities that rely on space-based assets.[16] In the past two decades, China fielded a wide array of counterspace capabilities built to attack each of the three necessary elements for space operations, satellites, ground stations and communications links, including ground-based, direct-ascent ASATs; on-orbit kill vehicles, ground-based lasers; cyber weapons; and jammers.[17] It is important to realize China's development of space capabilities is following a strategic campaign to innovate and enhance their space superiority tool kit. These are not one-off demonstrations or theoretical capabilities; they are designed to fight and win in a future conflict.

Space control comprises the activities required to contest and control the space domain. The desired outcome is space superiority. Space control consists of offensive and defensive actions, referred to as counterspace operations.

Counterspace operations are conducted across the space, electromagnetic spectrum, and ground segments of the space architecture.

Source: *Military Space Operations Terms of Reference*, September 2024, paragraph 3.1.

To that point, the 2007 ASAT test was not a lone incident. The Defense Intelligence Agency assessed that China launched a similar demonstration in 2013, reaching an altitude of approximately 30,000 kilometers. This altitude is significant because it is within the range of geostationary satellites. This suggests that China could have the ability to use ASATs against satellites throughout all orbital regimes—low Earth orbit (LEO), medium Earth orbit (MEO), and geostationary orbit (GEO).[18] ASATs that can reach geostationary orbits threaten some of the most critical U.S. communications and missile warning assets, including those for nuclear command and control. In a conflict with China, these kinetic ASATs could be difficult for U.S. forces to find, track, and attack because they could potentially be road mobile.[19]

China has sustained its efforts to test a broad range of counterspace capabilities including co-orbital ASAT technology and robotic grappling arms that provide space-to-space kill capabilities.[20] It is important to note that China has already used many of its counterspace capabilities like ground-based lasers to blind U.S. satellites.[21] The clear intent behind these developments cannot be ignored. The fight is already underway, and the United States must address these threats. Too much is at stake to consider a "day without space."

China is not the only threat to U.S. spacepower. Russia is also pursuing space control technologies and has demonstrated its willingness to use them.[22] When Russia invaded Ukraine in 2022, its first move was to launch cyber-attacks against Ukraine's satellite internet service provider, ViaSat. Subsequently is has used GPS jamming and counter-ISR technologies to further support its invasion of Ukraine.[23]

The variety of counterspace weapons Russia continues to develop includes various electronic warfare systems and co-orbital and direct-ascent anti-satellite weapons, some of which can deliver nuclear warheads.[24] Russia has conducted numerous tests of close-approach and rendezvous technologies that can be used against assets in both LEO and GEO. Not only can these capabilities surveil U.S. and allied assets on orbit, but they could also be used as kinetic kill vehicles.[25] Additionally, Russia's Nudol direct-ascent ASAT successfully destroyed a satellite in 2021, and its S-500 anti-ballistic missile (ABM) system could target LEO satellites.[26] At the same time, Russia's laser systems, including the Peresvet mobile laser dazzler, shield its mobile Intercontinental Ballistic Missiles (ICBMs) from overhead imaging, hampering U.S. early warning satellite operations.

Russia is also developing electronic warfare capabilities that can target both GPS receivers and satellite communications to disrupt U.S. kill chains. This includes the Tirada-2 mobile uplink jammer and the R-339Zh Zhitel mobile downlink jammer.[27] It is also purportedly developing a program that would enable a fighter aircraft to launch an ASAT into orbit.[28] An air-launched ASAT capability, whether carrying a kinetic payload or not, poses a highly agile threat to U.S. and allied space operations that could be especially difficult to defend against, much less counter.

Perhaps the most concerning development, however, is that Russia launched an on-orbit ASAT testbed capable of employing a nuclear weapon.[29] General Stephen Whiting, Commander of U.S. Space Command, highlighted the brazenness of this provocation: "A nuclear weapon on orbit represents wanton irresponsibility." This action, if exercised, would be a clear violation of the 1967 Outer Space Treaty.[30]

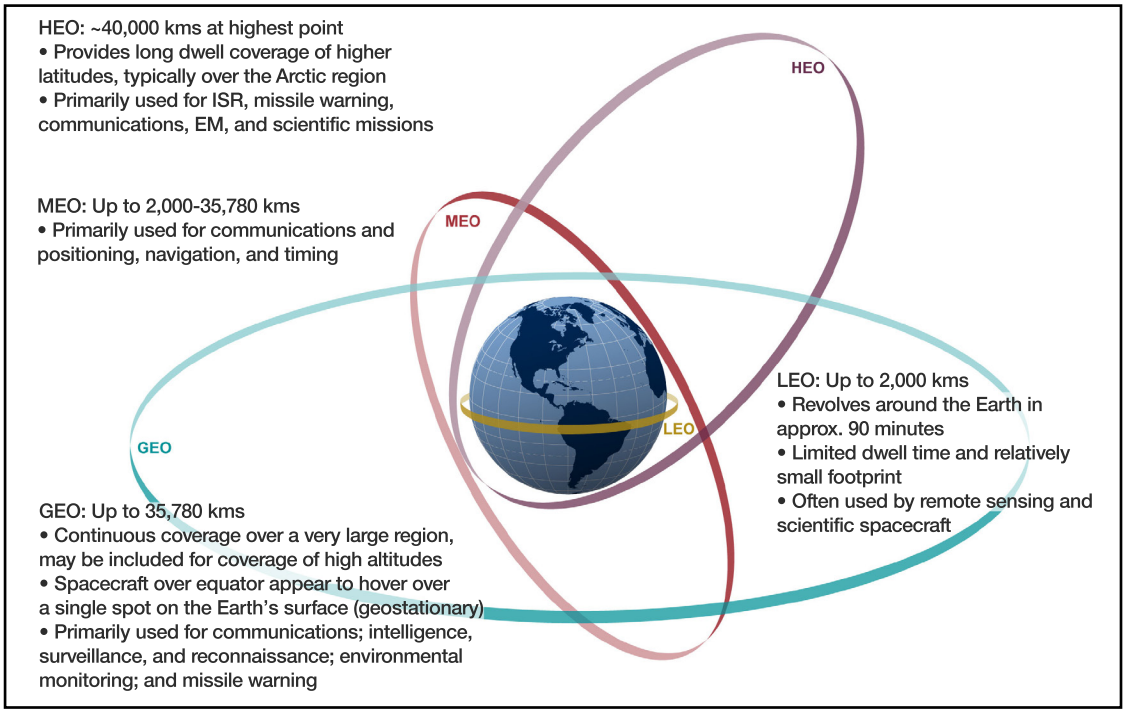

Figure 2: Orbital regimes.

Credit: GAO and Mitchell Institute.

In some respects, Russia can afford to assume more risk in space because it enjoys a specific geostrategic advantage. Its territory stretches over a broad expanse of the Earth's surface in the northern hemisphere, which requires it to rely more heavily on less-used and less-crowded highly elliptical orbits rather than the LEO, MEO, and GEO orbits that are most commonly used by the United States and its NATO allies (see Figure 2). Should Russia kinetically attack U.S. satellites in those more common orbits, it will create an outsized debris effect in those targeted orbits with a lesser impact to its assets in highly elliptical orbits.

The notion of Russia willingly injecting space debris into orbit as part of a counterspace campaign is not far-fetched. They are a declining space power with a reduced dependence on space compared to the United States and NATO. Its decision-makers are emboldened to choose more indiscriminate, risky, and destructive counterspace activities like widespread GPS jamming, debris-causing kinetic attacks, and even the threat of nuclear weapons in space.[31] Their continued violation of international norms and treaties further fuels concern for hostile actions in space. Moreover, Russia possesses the counterspace weapons to achieve these results. This combination of technical means, demonstrated aggressive tendencies, and their declining dependence on space yields a unique threat to U.S. spacepower.[32]

The scope, scale, and unique nuances of adversary space and counterspace capabilities demand a comprehensive response—U.S. Space Command and the Space Force cannot do it alone. Operations in all domains, conducted by combatant commands globally, are required to generate the needed cross-domain effects essential to gaining and maintaining space superiority. Space must now be supported. And the terrestrial services must field the necessary weapons to provide this support.

The Proliferation of Commercial Space: A Military Defense Problem

The U.S. military is responsible for ensuring the freedom of use of all U.S. space assets, whether they are military, civil, and commercial applications. This challenge grew significantly over the past decade due to commercial space sector booms. The commercialization of the space launch enterprise made access to space reliable and relatively cheap, which has helped dramatically increase the volume of satellites in space. For example, in 2007, fewer than 1,000 functioning satellites orbited the Earth. Today there are over 12,000. These military and commercial satellite constellations enable entirely new capabilities that benefit the U.S. and global economies, as well as U.S. national security. Their collective importance to the safety and wellbeing of the United States and its allies are why military efforts are not only warranted but also needed to defend them.

Much in the same way that the U.S. Navy protects the global commons and the freedom to use and navigate in international waters, so too must the Space Force and Space Command seek to preserve the use of the space domain for military, civil, commercial, and international interests.

Why Space Superiority Requires New Thinking About Cross-Domain Operations

U.S. Space Command and the U.S. Space Force were established to provide enhanced spacepower leadership, advocacy, and bureaucratic heft in an era where space is now a contested operating environment and yet demand for space-based effects continue to surge. The 2018 National Defense Strategy was a major harbinger in this evolution. Prior to 2018, U.S. policy shied away from even recognizing the vulnerability of the domain. It was the first time that the U.S. government officially identified space as a warfighting domain, acknowledging both the growing threats in space and U.S. reliance on it.

While these developments were step functions in the right direction, the U.S. military's space operations remain only partly transformed to meet the demands of the Third Space Age. A true paradigm shift will see terrestrially focused services and COCOMs significantly assist the space mission in support of SPACECOM. Future victory on orbit will require cross-domain operations to gain and maintain space superiority by protecting all segments of the space domain while denying U.S. adversaries access to and use of their space capabilities. This will require a major cultural transformation within the DoD: from one that sees SPACECOM as a *supporting* command to one where SPACECOM may also become a *supported* command. As such, DoD policymakers and warfighters from all services must better understand how space systems and their intrinsic characteristics work to sustain the U.S. economy and deliver the capabilities the U.S. military relies upon in peace and across the range of military operations.

U.S. Space Superiority Must Protect and Defend Civil and Commercial Constellations Against Adversaries

In the Third Space Age, the utility of military and commercial space systems for non-military functions exploded. The increased reliance on space effects and the blurring of lines between military and civilian use have left the United States and its allies even more vulnerable to attacks on any space system. For example, Ukraine was using ViaSat commercial communications satellites for command and control before the Russian invasion in 2022. Russia immediately jammed the satellites to blunt Ukraine's military effectiveness. Space superiority, therefore, requires extending defense to civil and commercial functions and not just military systems. To refrain from their defense simply means that future adversaries may jam, damage, or destroy commercial space systems that U.S. military forces and national command authorities rely upon. The DoD must prioritize actions in all domains and across all combatant commands to support space superiority and the continued unhindered access to space for all users.

The Very Basics on Space Systems & Why They Matter

Leaders, policymakers, and warfighters must all understand what constitutes a space system to protect U.S. space assets and exploit adversary space vulnerabilities to achieve space superiority. First, all space systems comprise three common elements: an orbital segment, a terrestrial segment, and the links that connect them.[33] Of these three segments, only the orbital segment resides solely in the space domain. The other segments traverse or reside in other domains. Because space systems inhabit all domains, they can be targeted in all domains. If any one segment becomes compromised or degraded, it could prevent a space system from performing its missions. Military actors in the air, ground, maritime and cyber forces must be aware of the portion of responsibility they share when it comes to countering adversary counterspace operations and holding adversary space capabilities at risk, with the unifying goal of securing space superiority.

The orbital segment, or the satellite, is the element physically in space that is most associated as the space system. In its most basic form, the satellite can be thought of as the bus—those systems which sustain its functionality—and the payload. Both the bus and payload subsystems are subject to attack vectors from an adversary.

The bus includes the satellite's power control subsystem typically comprising solar arrays, batteries, and power distribution electronics that ensure all components of the satellite are properly powered. The thermal control subsystem maintains acceptable temperature ranges for various other

subsystems. The propulsion subsystem enables a satellite to either stay in its defined orbit or move to another orbit as commanded by a ground station. Communications subsystems transmit the data mission payloads collect and are also critical to satellite bus operations.

The payload comprises those elements directly associated with conducting the satellite's mission. Mission payloads can range from missile warning sensors to electro-optical, infrared, or radar imaging packages on ISR satellites. Systems for weather sensing, spectral imagery for various purposes, and navigation and timing packages on GPS are all common satellite payloads.

Any one of a satellite's subsystems can be targeted in various ways. There are reversible (temporary) and non-reversible (permanent) effects, kinetic and non-kinetic. Ground-based spoofing of navigation and timing signals, jamming of communication links, and land- and sea-based laser dazzlers next to imagery targets temporarily blind ISR satellites, while an air-launched ASAT is a kinetic and non-reversible effect that can destroy the satellite. These counterspace operations can be delivered using cross-domain capabilities.

The terrestrial segment is made up of both a command and control element and a user element. The command element comprises the human operators, the computer terminals and ground stations, as well as the hardware that transmits the command uplinks to control the satellite's bus and payload systems and the telemetry downlinks that report on the health of the satellite and payload product. The user segment comprises the people and systems that consume the products of the satellite's payload system but are generally unable to command the satellite themselves. Examples include precision-guided weapons that receive GPS signals to direct it to target, soldiers using SATCOM radios to transmit or receive communications, or even citizens that receive streaming video across a satellite.

Depending on the satellite system, both the command-and-control element and the user element may be perfect targets for exploitation. Dropping a bomb on a satellite ground station to destroy the command and control computers, processing, and operators is one means to disrupt the terrestrial segment. Similarly, a ground station could be disabled through cyber-attacks. GPS jamming is a commonplace example focused on denying the user access to the benefit or function of the satellite's payload.

The link segment is the signal that connects the orbital and terrestrial segments. It transits multiple domains using the electromagnetic spectrum and faces some of the same electronic warfare threats as capabilities in terrestrial domains. For example, jamming or spoofing the command-and-control as well as payload product links can affect the viability of a space system. Jammers can be ground-, maritime-, or air-based depending on the specific target, tactic, and desired effect.

The Basics about Orbits & Why They Matter

All warfighters must have a basic understanding of what the orbital regimes are, their key attributes, and how they enable or constrain space capabilities to plan and execute cross-domain operations in support of space superiority.

First and most importantly, is that objects in space are not stationary but move in predictable patterns around the Earth. That predictable path is the satellite's orbit. Many variables will change an orbit, including the altitude of the satellite, how round or oblong the orbit is, and the satellite's orbital inclination relative to the equator, among others. Satellites will move faster or slower depending on the altitude of its orbit.

At the most basic level, the primary characteristic defining LEO, MEO, and GEO orbital regimes is their altitude (see figure 2). Each of these orbits has capability and vulnerability trade-offs suited to different operational needs.

Geostationary orbits are 35,700 kilometers above the Earth and their orbital plane is aligned with the Earth's equator. A system in GEO needs only three satellites to provide near global coverage. Due to their altitude and the speed of their orbit, GEO satellites appear to "hover" relative to a fixed location on the Earth. GEO satellites are optimized for large bandwidth communications and missile warning missions. However, they cannot "see" the Earth's polar regions and have challenges with providing higher-resolution imagery and signal strengths due to the altitude of the orbit. On the other hand, these distances keep them out of reach of typical direct-ascent or directed energy anti-satellite weapons. Terrestrial planners and commanders would likely need to attack the ground or link segments to deny, disrupt, degrade, or destroy a space system whose satellite is in GEO.

Satellites in MEO orbits (from 2,000 to 37,000 kilometers above the Earth) can obtain global coverage that includes the polar regions with an increased but relatively small number of satellites. Continuous coverage from MEO requires multiple satellites in multiple planes: the MEO GPS constellation, for example, needs 24 satellites in six orbital planes to achieve global coverage (see Figure 3.) Overlapping coverage created by constellations like this can mitigate the threat from individual ASATs, but, at the same time, terrestrial jamming of the user segment can be highly effective against a space system operating in MEO.

Satellites in LEO move very fast around the Earth, spending only 11–15 minutes in view of any given terrestrial point. Their altitude is up to 2,000 kilometers above the planet, and the speed of their orbit means that they cannot individually provide persistent coverage of a target area. Their low altitude enables them to have very high-fidelity imaging resolutions and more powerful signal strengths than satellites in higher orbits. However, their low orbital altitudes make them very susceptible to kinetic and laser ASAT threats from air, land, and sea.

The highly elliptical orbit (HEO) is a special regime that is used to cover higher latitudes (to include the polar regions) and typically dwell over the northern hemisphere for most of their 12-hour revolution. Because the altitude of HEO satellites varies as they complete their orbits, attacking a HEO satellite is complex. Link segment jamming may be necessary while the satellite is at its furthest point, where it also spends the majority of its time and conducts its mission. Direct-ascent or laser counterspace systems may be more appropriate while the satellite is at its lowest point of orbit. However, the opportunities to attack a HEO satellite at these points are limited to windows in which the systems are on the opposite side of the Earth to where they conduct their mission, and any attempt would require the close coordination of multiple geographic commands. This fact highlights the global nature of achieving space superiority, even in a regional conflict.

This basic understanding of the foundational precepts of orbital mechanics is important to terrestrial military planners and decision-makers who will be responsible for cross domain operations in support of space.

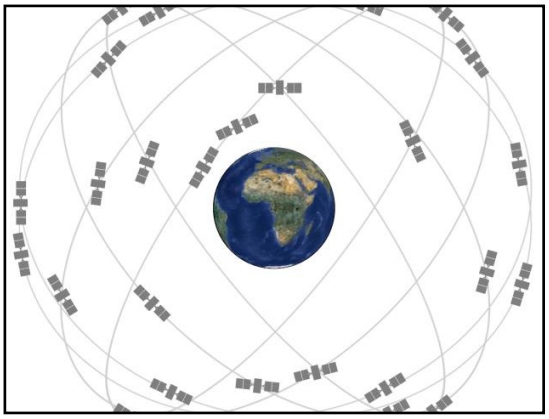

Figure 3: Notional GPS Constellation.
Credit: GPS.gov.

Cross-Domain Operations to Achieve Space Superiority

Gaining and maintaining superiority in any other physical warfighting domain requires the geographic combatant command to lead the main effort, with other combatant commands in support. Superiority in the space domain is no different. SPACECOM must be the supported command when securing space superiority. The challenge is that this is a fundamental shift in the culture of the terrestrial services, in which decades of operations and training treated space assets as supporting capabilities.

Yet, with the introduction of new threats that can challenge the ability of U.S. space assets to deliver effects critical to modern warfighting, any conflict in any theater will likely spill over into space and indeed, may start there. Moreover, all three elements of space systems present a range of vulnerabilities that adversaries can exploit to prevent U.S. forces accessing their space capabilities. At the same time, these very same characteristics in adversary space systems also present opportunities to U.S. and coalition forces to deny adversaries from using their space systems. Attaining superiority in the contested space domain requires specific operational activities across domains to protect U.S. assets and deny U.S. adversaries' ability to use their space assets. This is now U.S. Space Command's top priority, and terrestrial warfighting entities across DoD must do what they have never been asked before: prioritize space superiority in support of SPACECOM.[34]

This means that combat operations across multiple combatant commands include the requirement to support SPACECOM, even as forces in other combatant commands fight terrestrially. Space superiority operations with air, land and maritime forces must prioritize prosecuting terrestrial-based space targets such as user and command-and-control elements, space surveillance systems, or known ASAT launch facilities, for example. In addition to these kinetic operations, cyber forces can contribute with attacks on the command links between ground stations and satellites. EW assets can prioritize jamming user signals of various space systems. These actions must be coordinated by SPACECOM, but must also become second nature to forces operating in all domains. Whereas space superiority underpins all U.S. military operations, every service/functional component must contribute to achieving it.

The DoD has several initial tasks it must tackle to prepare warfighters, combat systems, and service organizations to realize effective cross-domain operations to gain and maintain space superiority. The DoD currently lacks definitive guidance regarding which organizations will fulfill specific roles and what their responsibilities are in securing space superiority. It also lacks guidance regarding how the terrestrial services should pursue counterspace systems development, acquisitions, and operations. A deficiency of basic space knowledge across the DoD further hinders operational planning and execution. Finally, space operations must be better integrated across joint exercises to give warfighters the experience in employing their service capabilities to gain and maintain space superiority in a contested environment.

"Dominance in space is essential to the nation's security and economic well-being."

-CSO General B. Chance Saltzman

Time for a Roles & Missions Review: Outlining Responsibilities Fundamental to Space Superiority

A main driver behind the stand up of the U.S. Space Force and Space Command centered upon the need for greater mission integration. As then-Vice President Mike Pence explained in 2019, "Responsibility for our national-security space programs is spread across more than 60 departments and agencies, resulting in a glaring lack of leadership and accountability that undermines our combatant commanders and puts our warfighters at risk."[35] He was exactly right. However, the rapid stand-up of the U.S. Space Force and SPACECOM stymied efforts to consolidate effectively. Internal friction and turf battles within the defense establishment preserved unnecessary mission overlap with multiple legacy organizations across the DoD and the intelligence agencies. Six years later, it is past time to review the entire national security space architecture to evaluate whether greater transformation and further deliberate reassigning of responsibilities is needed to achieve the intended streamlined and centralized space control establishment. This assessment should not be a one-off effort: roles and responsibilities must continue to evolve as spacepower continues to develop.

A roles and missions review is not just about protecting service or other organizational equities. Mission effectiveness must always drive organizational form. It does this in two major ways. First, each organization in the DoD must understand the part it plays in being supported *and providing support to* other warfighting organizations. In the past, combatant commands were only supported by space capabilities. Each service must now learn how to provide support to SPACECOM. Numerous space-support functions—like an air strike against an ASAT launch site, air and missile defense to protect a terrestrial downlink facility, or cyber security to protect connectivity—will always involve other service component capabilities and COCOMs who control the preponderance of forces in the relevant area of responsibility. The magnitude of this cultural and operational shift cannot be overstated. Each service and COCOM can provide cross-domain effects to support space domain awareness and prosecute adversary space and counterspace targets. Establishing and clarifying the roles and missions to achieve these effects will improve joint lethality, effectiveness, and efficiency.

Second, the duplication of effort in space control capabilities absent SPACECOM command and control is dangerous. Services other than the Space Force should absolutely own and operating counterspace capabilities but must do so through the common command of SPACECOM. Without this, space control operations to supposedly support specific tactical ground operations could potentially undercut larger or other operations in the space domain controlled by SPACECOM. The entire point of creating these organizations was to unify efforts and concentrate resources for best effect. That objective fragments when services begin developing their own organic mini-Space Forces for their own organic purposes. Consider recent statements by the Army calling for their own space capabilities and organizational constructs.[36] This flies in the face of core joint principles that emphasize interdependence, not repetitive stove-piped capabilities in each service. Services exist to organize, train, and equip in their specific core competency areas to provide capabilities to COCOMs, who aggregate mission functions and execute operational missions, including warfighting. Simply put, gaining and maintain space superiority and space support to the terrestrial COCOMs is SPACECOM's responsibility. The organize, train, and equip functions of terrestrial-based counterspace capabilities is every service's responsibility.

Considering the reality of fiscal constraints in the current budget environment and the need to rapidly scale spacepower capacity, ensuring the right systems are pursued in an organized, deliberate fashion to achieve the necessary effects at an appropriate pace and scale is paramount. Only the U.S. Space Force has the insight and oversight across the space capability portfolio to understand the integration of assets and tradeoffs within the military space architecture. The administration and DoD must ensure that they allocate resources appropriately to each service and space-responsible agency. This can only be done if every organization is clear on what its responsibilities are and that those responsibilities are both deconflicted and synergistic for efficiency and effectiveness. For example, it would be clearly odd and counterproductive if the Navy began procuring tanks and other armor capabilities for land warfare. However, it does make sense for the Navy to procure systems that can be launched from the maritime domain to support land operations of the U.S. Army and Marines.

The need for organizational clarity extends beyond the service branches. The longstanding boundary between DoD and intelligence community (IC) space activities remains an area needing further clarity to ensure threat awareness and countermeasures are integrated in the pursuit of space superiority. This is especially true as missions like real-time Air- and Ground-Moving Target Indicator (AMTI/GMTI) operations, which predominantly support terrestrial COCOM operational and tactical maneuvers, migrate to space. Those space-based capabilities must be operated by Space Force personnel in support of terrestrial COCOMs, not the space intelligence community to ensure terrestrial warfighters get the space-based services they require at the speed and scale required by mission parameters.[37] Furthermore, there continues to be a level of unnecessary duplication of mission. More than a dozen major defense and intelligence organizations have roles in daily and wartime military space operations.[38] When roles are unclear, missions can be double-resourced or neglected altogether—both outcomes are dangerous and wasteful and may jeopardize space superiority.

Space responsibilities across the combatant commands must also be explicitly identified. Simple constructs for how SPACECOM acts in support of other combatant commands in terrestrial combat operations are well known. What is not well known is how the other combatant commands should work together to support SPACECOM operations: when space targets on the ground must be struck, when signals must be jammed in a particular location, or when to provide additional capabilities when more than one combatant command needs resources from SPACECOM—optimizing GPS or communications satellite coverage for several geographical areas, for example. These scenarios must be thought through, validated by exercises, and documented in doctrine and planning for future operational situations.

The bottom line is, the time has come to scrub who is doing what when it comes to achieving space superiority. Intelligence agencies, allies, and commercial partners all contribute to the national security space architecture and have a role in achieving space superiority. Each entity must understand where it fits in, both in peacetime and during conflict, and SPACECOM must know what tasks these organizations will and will not cover. SPACECOM must also have oversight over where new technology or additional depth of capacity is needed in space operations. All this must be mapped out today, because the nation cannot wait to identify these roles and responsibilities during a war.

Clarity in where responsibilities lie is not bureaucratic housekeeping: it is a prerequisite for unity of effort, operational efficiency, and strategic deterrence. Operations, battles, and even wars have been lost for want of this organizational clarity. It is what prompted the Goldwater-Nichols reorganization efforts in the 1980s to promote effective joint operations. Joint lethality demands this unity and efficiency. Simply put, there has been no holistic review of roles and missions since the standup of the two military organizations responsible for space superiority, leaving the mission at risk. It is time for that to occur.

Technology: Smart Investments Lead to Advancing Capability

Cutting edge technology has defined every space age. Today and in the future, this will be no different: dominance in space requires superior cross-domain capabilities. Defining the roles and responsibilities of each of the entities that participate in the U.S. national security space enterprise will illuminate capability gaps and where the nation must invest in new technology. Integrating new technologies into the U.S. space architecture must ensure seamless domain awareness and enable cross-domain operations to effectively prosecute space-related targets and yield desired results. Achieving that goal requires fiscal investment to develop, field, and integrate these capabilities. Failing to keep pace with technological change often results in strategic surprise.

Domain Awareness Underpins Everything

Space Domain Awareness is a prerequisite to achieving space superiority. It has two parts: understanding the situation in space and gaining insight into space-related activities in other domains. Even in peacetime, awareness in the space domain is difficult to maintain due to the scope and distances involved. Seeing into GEO, for example, to witness a Chinese satellite with a robotic grappling arm "snuggle up" to a U.S. satellite is challenging due the distances and the need for specialized equipment.

Achieving awareness of space activities to support space superiority operations is a monumental, highly technical challenge that is only growing. The past 20 years saw the number of objects in orbit grow from approximately 10,000 to 40,000 (with most of the growth in LEO).[39] This rapid increase represents both the introduction of a greater number of operational satellites and the creation of potentially damaging debris from various ASAT tests or inadvertent collisions. As this number grows, so too, does the need for more and better space domain awareness.[40] Ground-based sensors procured and operated by the Space Force for SPACECOM form the backbone of the Space Surveillance Network (SSN). These fixed assets are complemented by a handful of space-based sensors that must observe everything in orbit, both friendly and not. However, the existing network is now overtaxed, and monitoring U.S. space-related activities in addition to potential threats from the air, land, maritime, and cyber domains in wartime will magnify the space situational awareness challenge.[41] While the U.S. Space Force continues to develop dedicated domain awareness sensors, weapon systems from other services (e.g. Navy Aegis and Army THAAD radars) can augment those capabilities. These same systems could be used in certain situations to provide warning of direct ascent ASAT missile launches.

Each service already possesses capabilities and operational practices to maintain awareness of their primary areas of responsibility. Recognizing that adversary space systems and threats can operate in all domains means that each service can employ their assets to provide valuable insight on the range of adversary activities that seek to undermine U.S. space superiority. The challenge is to integrate these fielded capabilities into SPACECOM's situational awareness and attack warning systems.

Air, land, maritime, and even space systems intended to support terrestrial domain operations can likewise provide significant support to general space domain awareness. Fifth-generation aircraft like the F-35, for example, are highly adept at collecting a wide spectrum of data, including information about the electromagnetic environment. Exploiting this data to determine the source and nature of EW threats to U.S. space systems can help other forces to target these threats. Similarly, some Space Force systems intended to support air and ground operations can contribute to multi-domain space awareness. Space-based tactical ISR constellations can support missile tracking, and future AMTI/GMTI sensors could contribute to SPACECOM awareness of airborne space threats. However, to realize these capabilities, it is critical to ensure that the Proliferated Warfighting Satellite Architecture (PWSA) missile tracking layer and GMTI constellations remain funded and on schedule.

Command, Control, & Communications to Integrate Joint Effects

Multi-domain space awareness data must be shared and synthesized to enable operations across the entire warfighting force. The incredible volume of data traversing an equally incredible expanse will require secure, high-bandwidth communication. Legacy means are increasingly falling short, given burgeoning technological development. The scale of the upgrade needed is akin to the need to move from 1990s dial-up modems to higher bandwidth connections to support modern internet functionality. New optical (or laser) communications systems will be necessary to meet the high bandwidth demands of space-to-space and space-to-terrestrial links.

Good news exists on this front. As of August 2024, the Space Development Agency successfully tested laser links in support of its PWSA network. [42] These laser space-to-terrestrial solutions have the potential to dramatically increase data rates from assets on orbit to ground stations. Laser-based optical systems, with the potential for terabit-per-second data rates, offer increases in bandwidth that are orders-of-magnitude better when compared to the current radio-frequency systems.[43] Additionally, the narrow beams of laser communications will greatly reduce the potential for adversaries to detect, intercept, or jam them. Other services must be able to tie into this network of optical communication nodes as well to relay their awareness data and coordinate execution of selected engagement options.

Space Force Domain Awareness Upgrades

Ongoing Space Force developments are aimed at improving the tracking of smaller objects and enhancing coverage of deep space, ultimately strengthening overall space situational awareness capabilities.

The **Space Fence** program introduced new S-band phased array radars for tracking small objects, with the first site on Kwajalein Atoll now operational.

The **Deep Space Advanced Radar Capability (DARC)** project aims to deploy three new all-day, all-weather radars for tracking objects in deep space. The placement of these satellites over points in Australia, the United States, and the UK will ensure global coverage.

The **MOSSAIC program** (Maintenance of Space Situational Awareness Integrated Capabilities) is focused on upgrading Ground-Based Electro-Optical Deep Space Surveillance (GEODSS) sensors and expanding the number of telescope locations.

As both military and commercial operations in the space domain continue to proliferate, the capacity of the entire Space Surveillance Network must also grow.

Harnessing laser communications technologies will help speed the maturation of the U.S. military's space situational awareness and enhance all SPACECOM service components' ability to conduct effective counterspace operations to secure SPACECOM's space superiority mission. Further investment in secure and survivable high-bandwidth communications links is essential. Without effective connectivity, the individual technologies are useless. Disaggregated, collaborative effects—which defines modern spacepower and terrestrial teaming—requires effective links that will endure amidst adversary attempts to interfere with U.S. operations to disrupt, degrade, or counter its attacks.

Engaging the Orbital Segment of Space Systems

Kinetically engaging the orbital segment is the most challenging and controversial approach to addressing threats in the space domain. The Soviet Union conducted 23 co-orbital ASAT test launches and 7 interceptions between 1967 and 1972 and continued to engineer various ultimately unsuccessful ASAT programs through the 1980s. Examples of past U.S. experiences include the F-15 ASAT test of 1985 and Operation Burnt Frost in 2008, in which an Aegis cruiser launched a specially modified SM-3 missile to destroy a non-functioning satellite because it had the potential to spread hazardous chemicals across populated areas. The United States never operationalized either of these systems, primarily due to the debris danger, but the potential exists to initiate similar efforts if necessary to achieve space superiority.

U.S. national policy should allow ASAT activities, because adversaries like China and Russia possess operational means to destroy our satellites and have previously demonstrated these capabilities. Direct-ascent, laser and electronic warfare capabilities fielded by Army, Naval and Air Force forces but commanded and controlled by SPACECOM will be key to achieving space superiority in any future conflict with China or Russia. While it is true that such strikes may yield debris in particularly useful orbits, the reality is that the United States must develop these capabilities to keep as an option in their toolset—for both deterrent and operational effects. Ceding this space to adversaries absent the ability to exact a commensurate toll on their space architecture simply increases the odds of a kinetic enemy attack in space.

However, kinetic attacks in space should not be the first or only engagement option to secure desired effects. Alternate means to secure space superiority exist that do not pollute orbits. Examples include "dazzling" satellites with lasers to temporarily blind their sensors. Higher-power lasers or electro-magnetic pulse weapons can damage, disable, or destroy a satellite without generating debris. Moreover, a single directed energy system (e.g. lasers) could engage multiple targets to generate effects at scale—certainly more than a "one-shot, one-kill" ASAT missile. Similarly, EW capabilities that can jam adversary satellite command and control or user links could be deployed with land, naval and Air Force units, but under the command and control of SPACECOM. These air-, land-, and sea-based options should be explored and jointly pursued. Numerous technologies have multi-domain applications. This kind of duplication for greater capacity is additive, not wasteful. Commanders always benefit from having a broader range of options, and multiple solution pathways complicate an enemy's decision-making and deters aggression.

Engaging the Terrestrial Segment of Space Systems

Disabling adversary space systems' terrestrial segments is likely the most accessible and effective cross-domain engagement strategy to achieve space superiority. This can be accomplished using any number of

conventional platforms, munitions, and non-kinetic effectors operating in the air, on land, at sea, and in the cyber domain. These methods can interfere with an adversary's ability to access data from space assets. Offensive capabilities are largely new requirements, which means the DoD must procure weapon systems and munitions in sufficient quantity to address the expanding list of adversary space-related targets. Existing inventories are already stretched too thin to service traditional target sets in a peer conflict.

These sorts of activities are not theoretical: strikes against terrestrial segment elements are already a proven tactic. During Operation Iraqi Freedom (OIF), an MQ-1 Predator drone strike destroyed an enemy satellite antenna on the ground, showcasing the precision capabilities of unmanned aerial vehicles in neutralizing space-related ground assets. The U.S. Air Force's strikes to eliminate Iraqi GPS jammers during OIF further illustrates the critical role of airpower in disrupting an adversary's counterspace capabilities in the terrestrial realm.

To realize the full potential of these multi-domain missions to help secure space superiority, the Joint Force Commander (JFC) and Joint Force Air, Maritime and Land Component Commanders must recognize, prioritize, and approve targeting adversary ground segments on the joint integrated priority targeting list (JIPTL) and allocate missions to those targets.

They must also regularly train to execute these functions, so tactics, techniques, and procedures (TTPs) are well understood. Succeeding amidst the pressure of combat is more than a "pickup game." A communications-denied environment in a highly contested, peer-level fight will demand that U.S. shooters depend more on their own organic sensing capabilities to close kill chains against adversary terrestrial space segments. Advanced airplanes like the F-22, F-35, F-47, B-2, B-21, EA-37B, and E-7, along with collaborative combat aircraft, as well as ground and maritime based systems like the Army Tactical Missile System (ATACMS), Long Range Hypersonic Weapon (LRHW), and Tomahawk Land Attack Missile (TLAM), will play critical roles in disabling adversary electronic warfare and counterspace systems.

In many ways, this mirrors the disproportionate value of F-117 stealth aircraft against Iraqi air defenses during the opening phase of Operation Desert Storm.[44] Similar stealthy, long-range strike capabilities will be in high demand to target adversary ground-based space sensing and command and control assets. These high-value targets typically enjoy the protection of residing deep within a nation's interior, where only a handful of stealthy, electronic warfare empowered airpower capabilities can reach. The additive mission of space superiority means that the Air Force should be considering procuring more of these advanced aircraft, not less. They are already a high-demand, low-density asset, and aircrews simply cannot do more with less.

Naval assets can also play a significant part in disrupting enemy spacepower capabilities. China, for example, currently operates naval assets to monitor satellites and space launch activities. It is also developing the capability for sea-based satellite launch. Traditional U.S. naval power and sea control activities, combined with airpower, can target these important functions to disrupt adversary space operations, sensing, and tracking. Together they can also project power inland to target space-related ground facilities. During operations like 1995's Deliberate Force and 1996's Desert Strike, destroyer-launched cruise missiles were highly effective against enemy C2, air and missile defense batteries, and radar installations. They could be just as effective on ground stations in the future, provided they are in range of the missiles.[45]

Ground-based kinetic strikes, though employed less commonly due to their inherent challenges with physics—namely range—offer another avenue to target the ground segment. Ukraine has successfully used the Army's High Mobility Artillery Rocket System (HIMARS), ATACMS, and fixed-wing drones to target critical Russian C2 and ISR installations. In May 2024, Ukraine even managed to damage a Russian ballistic missile warning radar using a *kamikaze* drone.[46]

The Army is doctrinally responsible for the preponderance of air and missile defenses that protect forward bases. Recent military activities in Ukraine, Russia, Israel, Iran, and the Red Sea clearly illustrate the growing nature of this threat—especially given the rise of low-cost missiles and drones. Forward-based U.S. space operating locations, especially downlink stations, are extremely vulnerable to surface attack. The Army will play a key role in defending them. This is a mission that needs significantly more investment, given that it is largely an unfunded mandate. U.S. forces cannot maintain space superiority if the terrestrial segments of the space enterprise are struck.

Special Operations Forces (SOF) can play a sizeable role in degrading adversary space systems, especially against the global distribution of Chinese space surveillance stations. Ideally, SOF forces should develop contingency plans to disable, disrupt, or destroy such ground assets early in a conflict to ensure they, and the effects they create, are removed from the adversary's order of battle.[47]

Non-kinetic cyber-attacks on ground station networks can also be instrumental to breaking adversary counterspace kill chains. The Russian cyber-attack against ViaSat at the outset of the Ukraine conflict demonstrated this principle and exposed the vulnerability of commercial satellite communication networks to digital warfare. Close integration between CYBERCOM, SPACECOM, and other geographic combatant commands will be crucial to coordinating the creation of desired cyber effects on space targets and avoiding inadvertent negative cyber effects on friendlies. Defensive cyber operations to protect critical infrastructure will likely have an outsized impact on space warfighting effectiveness, as the preponderance of U.S. space systems are CONUS-based.

Engaging the Link Segments of Space Systems

The U.S. military already possesses electronic warfare capabilities that can affect satellite communications links. U.S. forces lack sufficient capacity to fully address the range of targets anticipated in a fight with China. Developing new capabilities to disrupt the link segment of adversary space systems will remain a priority to achieving space superiority against peer adversaries.

The Space Force's globally deployed Counter Communications System (CCS) and the Army's Remote Modular Terminal (RMT) are current capabilities that can interfere with uplink satellite signals to geostationary orbit.[48] Downlink jamming capabilities also exist to disrupt the reception of satellite signals in localized areas. The mission of the U.S. Air Force's Compass Call aircraft includes communications and radar jamming and deception.[49] This inventory is already stretched too thin, with EA-37B buys cut in recent budgets. Capacity needs to reflect this new spacepower additive demand.

Looking past pure jamming, deception is an important tactic for achieving effects tied to spacepower. There are many reports of Ukrainian forces spoofing GPS to direct Russian *kamikaze* drones away from key targets. Deception presents adversaries with a particularly difficult challenge: whereas jamming simply denies the signals to users, spoofing inserts false data into users' devices, directing the users to unintended destinations.[50]

The U.S. Space Force should invest in improved counter-link capabilities such as the Meadowlands upgrade to the Counter Communication System, which will double its effective range while reducing its physical and power footprint.[51] Other services should ensure their electronic warfare operations against space targets are presented to SPACECOM for integration into the overall campaign plan. Luckily, all U.S. services are placing increased emphasis on these capabilities and should continue to do so.

For the United States to secure space superiority, it must possess satellite-, ground-, and link-segment counterspace systems that are responsive to an agile threat. Clearly, these systems operate in all the domains, not solely in space. All services must work to field systems to conduct these operations and make them available for joint, cross-domain space superiority operations. The DoD must recognize that space is a hostile domain, yet vitally important, and it requires significant investment to address these complex challenges from multiple azimuths.

Education: Increased Foundational Knowledge Leads to Greater Understanding

Technologies to achieve space superiority are only a piece of the overall puzzle: the education of joint warfighters is also vital to instill the criticality of space superiority. Cross-domain integration to achieve space superiority begins with cross-domain literacy. Too many warfighters across the services are unaware of the capabilities that space delivers—even those they use—and what they could do to help gain and maintain space superiority. As recently as February 2025, space leaders in INDOPACOM admitted that "most joint warfighters don't truly understand all of the space dependencies."[52] Without a shared lexicon and baseline of knowledge, effective integration remains impossible. Education is the bedrock of doctrinal evolution and combat execution.

The first problem is the general lack of space knowledge across the military services. The concept of gaining and maintaining space superiority in a contested environment with a peer adversary is even more novel. Space has been long regarded in planning, strategy, and doctrine as a mere supporting capability. U.S. forces must now prepare to protect their space capabilities as well as identify and exploit vulnerabilities of adversary space systems and segments. Prioritizing and prosecuting adversary space system targets across their orbital, terrestrial, and link segments must be a new but necessary component in cross-domain operational planning.

The Space Force, the Department of the Air Force, and the DoD must emphasize the space doctrine, threats, capabilities, and interdependencies that exist in this peer adversary competition. Improving communications and information sharing, including addressing the "need-to-know" classification mentality rife in space circles that hampers cross-domain collaboration, will be key to future U.S. space superiority success. By defining and explaining obscure but relevant terms, like space control and orbital warfare, the Chief of Space Operation's recently published Space Terms of Reference is a good start.[53] Education of all U.S. military members, not just Guardians, is paramount.

New Accessions

Accessions sources are a logical first step to ensure the appropriate exposure to and education about cross-domain space superiority is in place. Much like the rudimentary tenets of airpower, sea control, or ground warfare, the tenets of spacepower must be taught at the recruitment level to brand-new military members. All young service members should begin their military careers with a mindset of spacepower for peer competition. At this level, education should confer an understanding that space is vital to U.S. national interests, the Space

Force's core missions, and what warfighters must do to support space superiority. It should indoctrinate new members that every military service has a fundamental interest and obligation to contribute to gaining and maintaining space superiority, even as they pursue their own service-specific roles and missions. This awareness and orientation must be inculcated at the very earliest stages of accession, no matter the service. America does not have airpower, sea power, land power, cyber power, or amphibious power unless it has spacepower. That demands space superiority.

Targeted Professional Military Education Reform

Space-oriented education could have the biggest impact in service and joint professional military education (PME). At this phase in service members' careers, they can still recognize preconceived notions, misconceptions, and cultural biases. There, warfighters will have the opportunity to address these biases before they are advanced in the field. Additionally, exercises are conducted regularly during PME, and warfighters will be able to try out their new-found knowledge with colleagues from other specialties and services. It is crucial to educate these individuals that spacepower is not someone else's problem: it takes a joint effort.

The Space Force needs a space-focused advanced PME. Each service, except the Space Force, has an advanced mid-level PME: the School of Advanced Military Studies (SAMS) for the Army, the School of Advanced Air and Space Studies (SAASS) for the Air Force, the Maritime Advanced Warfighting School (MAWS) for the Navy, and the School of Advanced Warfighting (SAW) for the Marine Corps. These schools create strategists in their domain specialty who are afforded high levels of credibility among joint warfighters, smoothing the way for more integrated operations across the various domains. Cross-domain support of space superiority should be a top priority in each of these advanced strategy schools because, in truth, space capabilities are foundational to every service's pursuit of their own domain mastery. Moreover, while SAASS has space in the name, it is not focused on warfighting in space for space warriors, unlike each of the other schools. This should be rectified in the future with a dedicated space-focused advanced PME. Like SAMS, SAASS, MAWS, and SAW, the new advanced space PME will be an opportunity for joint education, thus advancing a deeper understanding of space superiority within all services.

Experience: Incorporating the Space Superiority Fight in Major Theater Exercises Leads to Improved Integration

While each theater has major exercises, few large-scale, multi-domain exercises incorporate space effects, much less space superiority, in their scenarios. Historically, "a day without space" scenarios proved to be too onerous to the exercise objectives to allow the contested condition to continue.[54] Space capabilities were "turned back on" after recognizing that forces could not survive or operate without space capabilities, and the nuanced lessons of doing what it took to gain and maintain space superiority were never discovered or exercised. If the U.S. military operated like that in the real world, they would lose. Modern combat demands fighting the space conflict. Enemies will not allow us to hand-wave it away. The U.S. military focuses tremendous energy on developing TTPs to successfully operate in contested terrestrial domain. This must also happen with the integration and defense of spacepower.

Every combatant command, service, and mission specialty must train to what their responsibilities would be in supporting SPACECOM to secure space superiority. Advanced space training capabilities, like the Space Force's Operational Test and Training

Infrastructure (OTTI), offer both real and virtual opportunities for the DOD to improve the realism of space-related training—not just for Guardians, but for all joint warfighters.

"We Fight Like We Train" Must Include Space

Gaining and maintaining space superiority should likewise be represented in all combatant command exercises as a line of effort. SPACECOM must practice being the supported command in a cross-domain fight. It is a common assumption that space effects like GPS, satellite communications, and weather data will always be accessible, often with the warfighter not knowing what must work to deliver the space effect.[55] Without understanding their own space dependencies, warfighters may not prioritize protecting at-risk space capabilities or prosecuting vulnerable adversary space capabilities—in other words, supporting space superiority. But real-world cross-domain operations can be risky if not first tested in training environments. Exercises are an important tool that large organizations like combatant commands use to train their members for real-world operations.

Barriers to incorporating space superiority scenarios into major exercises persist today and must be overcome. Classification is a major, perennial problem. Space capabilities are often so compartmentalized that the wider joint audience is unaware of their existence, much less their effects and vulnerabilities. The Space Force and DoD now have several initiatives working to address this issue, including an adjusted space acquisition strategy incorporating allies.[56] Warfighting capabilities and capacity are not effective if they are unknown, untested, and insufficiently integrated. There comes a point where classification may project more risk than benefit.

This increased access must also occur in major theater exercises where combatant commands train with allies and other partners. This broad engagement is vital for executing seamless real-world operations.[57] The USSF prioritizes allies as a key element of their strategic planning. For space exercises to be realistic, allies and partners must be included.

The lack of space personnel and planners in major theater planning constructs is another problem. Quality exercises and training demands expertise. There are limited numbers of space-knowledgeable personnel who can create scenarios, to include contested space situations, that show the relevance of space capabilities to other domains. Moreover, terrestrial combatant commands are still developing their own space components while key space organizations continue to be understaffed. Space planners must be embedded earlier and more consistently in joint planning and wargaming cycles across the services and combatant commands. Space Force end strength must grow to reflect these requirements. Spacepower will not be adequately represented and empowered if Guardians are always outnumbered and outranked. Current directed cuts to manning will negatively affect the ability to purposefully man elements in theater constructs and must be arrested.[58] The Space Force is already too small. In fact, most other services have individual bases with more personnel than the entire Space Force. Leaders need to appreciate what is being asked to a force that is already undersized. It is time to invest, not cut.

The bottom line is that commands must practice the cross-domain counterspace operations required in conflict. Budgets must also reflect these requirements—whether discussing people, technology, or training. Warfighters from different services and competencies must practice together to get it right before real resources, capabilities, and lives are at stake. Traditional geographic and functional combatant command members must experience supporting space operations before they are forced to for the first time in combat. Seeing through efforts like these is

"Spacepower is the ultimate team sport. Space is simply too complex, too vast, and too risky for any single power to control. Therefore, if the service is to achieve its mission to secure our nation's interests in, from, and to space, then it absolutely must cultivate partnerships with partners upon whom it can depend on to share its pursuit of a stable, secure, and sustainable domain."

-CSO General B. Chance Saltzman

imperative *before* a major conflict threatens U.S. space superiority. America cannot wait for a conflict to erupt before its warfighters learn how space and terrestrial forces operate as one—exercises have been and must remain the crucible where new doctrine for modern warfare is forged.

Conclusion & Recommendations

The Department of Defense must adopt a set of deliberate, reinforcing reforms across organizational responsibilities, education, and training now to achieve and maintain space superiority in an increasingly contested domain. These efforts should not be seen as isolated initiatives but as integrated elements of a broader campaign to shift the culture, capabilities, and command relationships that define space operations. Without these enhancements, space superiority will remain out of reach and leave the United States dangerously exposed. America may lose its next war in space unless the DoD, services, and the broader security community makes the necessary reforms now.

First, the Department of Defense must conduct a comprehensive review of space roles and missions across the national security space enterprise. Six years after the creation of the U.S. Space Force and U.S. Space Command, overlapping missions, unclear responsibilities, and inefficient resource allocation persists across the national security space enterprise. The Secretary of Defense should direct a formal review to clarify which organizations are responsible for what space-related functions in peacetime, crisis, and conflict. Centralization of space operations within the Space Force and Space Command should be the starting assumption. The first Trump administration was correct to form these organizations to yield a more integrated, centralized approach. To fully realize this vision, more work must be done.

This review must also define how other services and combatant commands support space superiority operations and how SPACECOM will prioritize competing demands across multiple theaters. Unity of effort in space begins with unity of understanding, and that cannot happen without institutional clarity.

The executive branch should also conduct a similar review across the broader national security space enterprise. The activities of the DoD, IC, and other government agencies conducting space activities must be refined and deconflicted. This may result in further consolidation of responsibilities or the establishment of clearer boundaries to ensure critical space systems have the protection and priority to assure space superiority for U.S. warfighters.

Second, the Department of Defense must prioritize investment in cross-domain capabilities that support space superiority. Insufficient cross-domain investment and integration leaves U.S. forces without the capabilities needed to achieve and sustain space superiority against advanced threats. This includes the development of not only counterspace systems across all segments of

Culture: The Hardest Barrier to Space Superiority

Management expert Peter Drucker is often credited with the phrase, "culture eats strategy for breakfast." Nowhere is this truer than in the U.S. military, where deep-seated service identities can shape, or obstruct, operational change. The reception of space-based capabilities has long revealed this tension. Fighter pilot Maj Gen Doug Pearson recently observed that, during the DoD's 1985 ASAT missile test series, integrating the two cultures of the space world with that of aviation proved even more difficult than physically integrating an ASAT missile with an F-15. Nearly four decades later, despite the creation of the U.S. Space Force and the outsized importance of space operations, cultural barriers remain.

Before 2007, our space capabilities that were critical to terrestrial forces were not threatened. As a result, space was treated as a supporting capability that would always be available to the terrestrial warfighting communities with little or no action required on their formations to assure they would receive those capabilities in a conflict. This is no longer the case. The terrestrial services must rapidly field capabilities that can support the SPACECOM mission to gain and maintain space superiority if they want to continue to deter, fight, and win as we did in Operation Desert Storm. No matter how robust the doctrine, how advanced the technology, or how clearly defined the command relationships are, achieving true cross-domain integration for space superiority will require a change in traditional approaches to Joint concepts and doctrine. Critical space capabilities are no longer a birthright but will have to be defended and our adversary's space capabilities must be defeated.

the space architecture—orbital, terrestrial, and link—but also enabling technologies such as optical communications for resilient data flow and expanded space domain awareness assets. Ground-based and airborne platforms such as the F-15EX, F-22, F-35, F-47, B-2, B-21, EA-37B, E-7, collaborative combat aircraft, THAAD, HIMARS, ATACMS, LRHW, drones, and Aegis-capable ships and their SM-3 and TLAM weapons, along with directed energy weapons from all domains should be integrated into counterspace kill chains. The joint examination of all available means to achieve space superiority is essential to deliver joint lethality and establish a proper alignment of resources to maximize cost per effect, regardless of service. America's defense dollars are limited, and mission demand is growing, so every dollar must yield optimized results.

Third, the Department of Defense must invest in foundational space education across the U.S. military. Most of the U.S. military lacks foundational space education, leaving most warfighters unprepared to fight in, around, or through the space domain. Every warfighter, regardless of service or specialty, must understand the basic mechanics, vulnerabilities, and operational value of space systems and how they contribute to their defense. This begins with the inclusion of space concepts in accession training and continues through targeted reform of Professional Military Education, especially at the intermediate and senior levels. Space doctrine, dependencies, and contested-space scenarios must be taught as standard joint warfighting concepts. Additionally, a new advanced space-focused PME program—comparable to SAASS, SAMS, or SAW—should be established to cultivate deep space warfighting expertise among future planners and leaders among all services.

Fourth, the Department of Defense must normalize contested space operations in joint exercises. Joint exercises largely sideline contested space scenarios, leaving the force unprepared to rehearse and fight for space superiority in realistic conditions. Space must be included not as a simulation,

script inject, or background enabler, but as a fully contested domain with lines of effort, adversarial actions, and clear operational objectives. Geographic combatant commands should rehearse supporting space superiority campaigns, just as SPACECOM must practice being the supported command in a cross-domain fight. Exercises must account for degraded or denied space capabilities and incorporate realistic scenarios that allow warfighters to rehearse gaining and maintaining space superiority. Classification barriers, manning shortfalls, and cultural inertia must be deliberately addressed to enable this transformation.

Together, these reforms represent a practical path toward achieving space superiority in a contested environment. They are not simply space policy upgrades; they are prerequisites for maintaining the military and economic advantages that space enables. The time for incrementalism has passed. The future of space superiority—and national security—depends on the Department's ability to embrace this transformation now.

Conclusion

The United States can no longer assume uncontested access to space. In this Third Space Age, space superiority must be secured through deliberate effort and cultural transformation across the Department of Defense—treating space as a warfighting domain where advantage must be gained, maintained, and, if lost, rapidly regained through coordinated cross-domain operations.

America *will* fight a future war in space. Adversaries are already contesting U.S. capabilities there every day. It is time to get serious about tackling that threat, but space superiority is not the sole responsibility of the Space Force or Space Command; it is a joint imperative demanding active participation from every service. Clarifying service roles and missions, investing in cross-domain capabilities, expanding space education, and integrating contested-space scenarios into major exercises are essential steps. These reforms require bold leadership, sustained investment, and unity of effort now—before future conflict imposes the lesson by force. ✪

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