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Redesigning Space Forces for Deterrence and Warfighting

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Introduction

With the end of the Cold War, threats to U.S. national interests in outer space were expected to diminish. The prospect of space being a benign environment affected decisions regarding U.S. national security space capabilities. Requirements for protection and defense were traded-off for cost savings and performance. In addition, security classification was relaxed, terrestrial backups were terminated, and priority for intelligence on foreign space capabilities and intentions was reduced.

Threats reemerged, however, with renewed great power competition. While the United States fought a global war on terror, Russia and China modernized their armed forces seeking to dominate spheres of influence and alter the international status quo. They studied the American way of war and recognized its reliance upon space systems for power projection. Moscow and Beijing prioritized acquiring space and counterspace capabilities to undermine U.S. strategic advantages in the domain. They view space as an arena in which assets can be held at risk for coercion.

Freedom of passage through and operations in space are now contested. Threats are fast paced, full spectrum, and cross-domain. Russia and China are fielding space and counterspace systems faster than America is fielding countermeasures. They are conducting provocative operations in the "grey zone" between peace and war. According to Vice Chief of Space Operations General David Thompson, "both China and Russia are regularly attacking U.S. satellites with non-kinetic means, including lasers, radio frequency jammers, and cyber-attacks."[1] In fact, Russia attacked ViaSat's and SpaceX's satellite internet networks as well as other civilian space assets during its aggression against Ukraine,[2] asserting commercial systems involved in the conflict are legitimate military targets.[3]

The United States is still adjusting to these threats as well as their implications for international relations and warfare. Despite altering national security space management and organization as well as allocating substantial resources for new space capabilities, America is not yet adequately prepared to deter or defeat the threat or use of armed force in space. Indeed, debate continues about how to redesign space force structure and posture for deterrence and warfighting. This paper critically examines the debate and addresses key considerations for designing future space forces to protect and advance U.S. national interests.

Debate

The debate was prompted by the implications of threats to U.S. interests in space. America is the world's leader in the exploration and use of space. It leverages that preeminent position for strategic advantage in terms of prestige, influence, knowledge, wealth, and power. Unimpeded access to and use of space is a vital national interest because of its overriding importance to the United States' vitality, integrity, and survival.

Space assets are woven into the nation's socioeconomic fabric, integrated into critical infrastructures, and enable critical missions and services. They impact Americans daily lives in countless ways usually taken for granted unless disrupted. Denial of mission-critical space capabilities could influence the course and outcome of conflict. Without the information collected, generated, and relayed by space assets, America could be reduced to an industrial-age economic and military power.

Foreign nations are developing, testing, and fielding an array of space weapons. While Russian and Chinese direct-ascent anti-satellite (ASAT) tests as well as Beijing's test of a hypersonic fractional orbital bombardment system (FOBS) garner the most attention, the danger includes cyber, electronic warfare, directed energy, and space-based weapons.[4] Long-range precision-strike systems and special forces also threaten launch ranges, ground stations, and supporting infrastructure. Moreover, while treaties prohibit mass destruction weapons placement and nuclear testing in space, electromagnetic pulse and other nuclear effects remain plausible threats.[5]

The U.S. government is aware of space systems' susceptibility and vulnerability. There is a consensus about improving their resilience, protection, and defense to deter or prevail in conflict. There is also general agreement that it is imprudent to rely upon small numbers of capital assets in fragile constellations, such assets must be protected and defended at least until greater resilience is achieved, and capabilities must be delivered and operated with agility at speeds relevant to the threat. There is no consensus, however, about future force structure or posture, how to improve resilience, how to leverage commercial and international capabilities, the relationship between offense and defense, or how to align military and other elements of national power for space security.

During the Cold War, space capabilities were integral to the U.S. grand strategy of containment underpinned by nuclear deterrence. They supported war planning, indications and warning, command, control, and communications, targeting, and weapons delivery. Policy guidance directed the Defense Department to ensure freedom of action in space for the U.S. and its allies and, if directed, deny such freedom of action to an adversary.[6] It emphasized the survivability and endurance of space systems commensurate with their planned use in crisis and conflict, threats, and other means to perform missions.[7]

America employed a mix of capabilities to protect and defend space systems against threats posed by the USSR. Protection involved various passive defense measures. The national reconnaissance program primarily relied upon secrecy to conceal the existence of imaging and signals intelligence assets, while the defense space program employed redundancy, autonomy, hardening, electronic, and other countermeasures.[8] Active defenses included direct-ascent ASATs to intercept FOBS.[9]

As post-Cold War U.S. strategy shifted from countering terrorism and weapons of mass destruction proliferation to managing great power competition, policy emphasis moved to mission assurance and resilience.[10] Mission assurance is a process to protect or ensure the continued function and resilience of space capabilities and assets critical to perform mission essential functions.[11] Resilience is the ability of an architecture to support the functions necessary for mission success, with higher probability, shorter periods of reduced capability, and across a wider range of scenarios, conditions, and threats, despite hostile actions or adverse conditions.[12]

The debate initially focused on whether to evolve "aggregated" architectures or "disaggregate" them.[13] Aggregation consolidates multiple missions on larger, more complex, multi-mission spacecraft in Geosynchronous Earth Orbit. Disaggregation separates strategic (nuclear) and tactical (nonnuclear) missions onto smaller, less complex, single-purpose spacecraft at other orbits.

Aggregated architectures were disparaged as "tethered Zeppelins in space" and "large, juicy targets."[14] Disaggregation advocates asserted it would decrease cost, reduce schedule, increase opportunities for technology insertion, and enhance deterrence. Indeed, they claimed mission separation would establish a "red line" to prevent inadvertent or unintentional escalation if platforms with both nuclear and nonnuclear missions were attacked during conventional hostilities.

The current phase of the debate is mainly about the relative merits of "proliferated" Low Earth Orbit (PLEO) architectures with large numbers of smaller, less complex, satellites. PLEO advocates assert it makes individual satellites less attractive targets and enables graceful degradation. They also argue commercial "mega-constellations," with hundreds or thousands of satellites, can be leveraged to decrease costs, increase technology insertion frequency, and host national security payloads.

Another facet of the debate involves active defense and arms control. The U.S. pursued ASATs and space-based missile defenses during the Cold War, intercepted an errant satellite whose uncontrolled reentry endangered populated areas, and acknowledges operating the Counter Communications System. General Kevin Chilton, former commander of U.S. Strategic Command, has noted, however, "the highest levels of government are uncomfortable discussing fielding the necessary offensive and defensive capabilities required to operate and survive in space."[15] He advocated treating space as other domains and fielding "weapon systems that can defend our assets and hold adversaries' space capabilities at immediate risk."[16]

Nonetheless, the U.S. government is emphasizing international norms of responsible behavior to reduce threats, which some view as an alternative to defense.[17] It condemned Russia's and China's irresponsible behavior in conducting destructive ASAT tests that generated large amounts of debris, jeopardizing flight safety and harming environmental sustainability, and orchestrated international opprobrium against the tests. Subsequently, the U.S. announced a unilateral commitment "not to conduct destructive, direct-ascent, ASAT missile tests" and called on other nations to follow suit.[18] Although some friendly nations have agreed to do so, neither Russia nor China expressed support.

Political-Strategic Considerations

The debate has mostly focused on tactical-technical matters. In part, this is because of a cultural inclination for technological solutions. Broader political-strategic and operational-level thought largely is absent. The lack of strategic and operational considerations neglects the fact that war beginning in or extending to space is a continuation of politics by violent means and, while human-machine interactions are central to modern warfare, conflict cannot simply be reduced to its tactical-technical dimension.

War in space could be a precursor of or escalate from terrestrial hostilities. America must be prepared for hostile acts to deceive, disrupt, deny, degrade, or destroy U.S. and friendly space systems. Attacks may involve non-kinetic, kinetic, and nuclear capabilities with temporary (reversible) or permanent (irreversible) effects generated, possibly without warning or attribution, in seconds, minutes, or hours. Their immediate impact as well as secondary and tertiary effects could be localized, regional, cascading, or global.

Timelines for making decisions about how to respond will be compressed. Options to prevent or respond to hostile uses of space, including whether to run escalatory risks (such as crossing the homeland threshold of a nuclear-armed enemy), depend upon force design. Given the implications of space warfare for victory, conquest, or possibly even national survival, the question of how much escalatory risk a President is willing to run is a critical policy matter. Moreover, the adversary will "get a vote" about methods of coercion, who fires first, and the conflict's intensity and scope.

The agility needed to address the speed of space warfare raises policy questions about deployment and employment authorities, particularly pre-delegation. It also raises questions about whether or when humans should be in or on the command-and-control loop. If compressed decision-making timelines require shifting from sense-decide-act to decide-sense-act cycles, should the U.S. move to pre-determined rule sets and artificial intelligence/machine learning enabled machine-to-machine interactions and effects delivery at speeds relevant to space battle?

Political sensitivity about space warfare inhibits intellectual rigor in thinking about the (latent or overt) threat and use of force in space. Consequently, the U.S. lacks the necessary policy, strategy, and doctrine to guide requirements generation, program acquisition, and war planning. Yet, policy guidance sets the strategic aims and boundary conditions necessary to formulate strategy, design force structure and posture, and develop war plans. It informs the operational performance required of forces in various contingencies.

The U.S. national security enterprise must know what is required of space forces, under what circumstances, and for how long to generate the capabilities and plans to achieve the ends established by policy. This includes guidance on what capabilities to conceal or reveal, and when to do so, for deterrent or warfighting effect.[19] The forces required to deter Russian aggression in Europe likely differ from those necessary to defend Taiwan from Chinese invasion or punish Iranian violence in the Middle East. Strategy relates ends to the ways and means of achieving them while doctrine informs how to employ means. Moreover, political constraints on capabilities, plans, and rules of engagement impact courses of action and tactical choices.

In this regard, the diplomatic, informational, and military instruments of national power must be aligned for an effective deterrent. Establishing international norms of responsible space operating behavior is a laudable goal, but norms reflect rather than create states' interests in avoiding conflict. When those interests no longer coincide, compliance with norms cannot be assumed. History demonstrates that nations tend to honor norms when least needed (in peacetime) and disregard them when most necessary (in crisis and conflict). At best, norms might be constructed to help discern threatening behaviors, provide indications and warning, and trigger counteractions.

Furthermore, the empirical record is not promising regarding arms control agreements that are effective, equitable, verifiable, and in the interests of the U.S. and its allies. Space arms control is beset by problems of definition, the variety of threats against space systems, dual-use technology, verifying compliance, and enforcement. Indeed, the latter are especially important when agreement depends upon the cooperation of partners with a propensity for cheating.

The absence of cogent policy leads to open questions regarding the use of force in space for national and collective self-defense. Long-standing U.S. policy states that: space systems are sovereign property with the right of passage through and operations in space without interference; "purposeful interference" is an infringement on sovereign rights; and the U.S. may respond in a time, place, and manner of its choosing, including with the use of force. In the absence of clear direction for response planning, such declaratory policy risks being hollow. Action policies are needed to guide force development, tests, exercises, deployments, and operations for strategic messaging, deterrence, reassurance, and warfighting.

Aside from what circumstances involving U.S. national security space assets might warrant the use of force for self-defense, operating forces need direction about defending U.S. citizens and property in space, U.S. commercial space assets, and other designated non-U.S. forces, foreign nationals, or property in space. Political priorities will help establish the proper approach to protection and defense. Given that military resources are likely to be constrained, priorities are essential for determining how to allocate scarce assets.

Deterrence and warfighting are two sides of the same coin. As the first U.S. commander-in-chief observed, "to be prepared for war is one of the most effectual means of preserving peace."[20] There is a positive correlation between resilience, protection, and defense on one hand

and deterrence on the other. Deterrence can be achieved by the threat of punishment or denial. Punishment involves the imposition of costs that exceed benefits; denial involves making benefits too difficult or costly to achieve. Resilience, protection, and defense are essential for deterrence-by-denial. Threats of punishment and denial can overlap and be used in combination. While punishment provides no protection if the threat is insufficient to prevent attack, denial provides a hedge by protecting retaliatory means if deterrence fails.

The lack of clear policy has fostered imprecision in language unnecessarily complicating deliberations. National security space tends to be an esoteric and technical subject with its own lexicon. Despite the shift from benign to contested domain, the U.S. Space Force's creation as the sixth armed service, and U.S. Space Command's reestablishment as a geographic combatant command, U.S. officials continue to speak in terms of space as an adjunct to, rather than leading edge and primary instrument of, information-age military power. Indeed, debate focuses on generic terms such as "architectures" rather than force structure and posture.

Moreover, force design analyses and deliberations predominately focus only on part of the space mission set – enhancing the operational effectiveness of terrestrial forces – in isolation. The relationships among offense, defense, and enablers must be considered. The Defense Department is, of course, in the business of deterring, fighting, and winning the nation's wars and must be able to articulate what is necessary to succeed in a contested, degraded, and operationally limited space environment.

Despite their distinct meaning for policy, requirements, acquisition, and operations, officials misuse terms such as security, protection, defense, survivability, endurance, continuity, assurance, and resilience as synonyms. Similarly, advocates of disaggregation cause confusion by conflating mission separation with proliferation and distribution (spreading mission capability across orbits, platforms, spectrum, and geography). Furthermore, the term "hybrid" is alternately used to describe either combinations of architectures (e.g., disaggregation, proliferation, and distribution), spacecraft sizes, or government and commercial space capabilities. The lack of consistently defined terms and imprecision in their use muddles debate.

While the challenge to space security is a complex, multivariate problem, analyses for decision support of policy formulation, requirements generation, force design, program acquisition, and resource allocation tend to be reductionist and search for simple answers. Yet, space mission capabilities involve networked systems-of-systems and supporting infrastructure. Space systems are comprised of launch, ground, orbital, link, and user segments. They operate concurrently in the terrestrial, cyber, and space domains. There are myriad passive and active measures that could be employed to evade, withstand, operate-through, degrade gracefully, suppress, destroy, and recover from threats.

Furthermore, the U.S. is confronting multiple adversaries with different leaders, cultures, histories, geographies, intentions, and capabilities. Space systems may be threatened or attacked to undermine political will, societal cohesion, and morale; harm economic vitality; thwart intelligence activities; and reduce the combat effectiveness of military forces. Adversaries may target political, economic, and symbolic as well as national security space assets. While the search for simple or single answers may be understandable, the inability to address complexity, grasp nuance, and think about space warfare at an operational level impedes determining how to redesign space forces.

Operational Considerations

Although space is a unique environment for military operations, distinct from the terrestrial or cyber domains, hostilities in space will have relevance only in relation to the course and outcome of conflict on Earth. Alternative force designs must be evaluated in the context of how campaigns and battles affect political-military events where humans live. The operational level is where the employment of specific capabilities is linked to achieving strategic objectives. Given limited empirical evidence from space conflict, prudence dictates avoiding deterministic assumptions. It is imprudent to expect that either side will have perfect domain awareness given the fog and friction of war. Similarly, it is unwise to assume the side that fires first will disarm its opponent even if it achieves surprise and seizes the initiative.

Rather than debate in reductionist terms, force designs must be evaluated regarding the operational dynamic of the space control mission. Space control entails ensuring U.S. and friendly forces have freedom of action in space while denying the adversary the same. It has two purposes: safeguard use of the domain for free exercise of U.S. and friendly forces; and prevent enemy use of space for hostile purposes. A rule of classical strategy is that securing military control of a domain is a prerequisite for its exploitation. If space forces are to perform their roles and functions in joint or combined operations, they must first succeed in space. To utilize space as a force multiplier, freedom of action in space must be assured.

The outcome of a campaign to secure control of the space lines of communications and key orbits could range from undisputed command, to working control, to reciprocal denial. Space control cannot be shared. Nations cannot simultaneously control the same orbits. Although analogies from other domains have limitations, space control (like sea control) can be envisioned as a moving zone of control in orbit rather than as a permanently occupied and fortified position.

Alfred Thayer Mahan described undisputed command as "the possession of that overbearing power on the sea that drives the enemy's flag from it or allows it to appear only as a fugitive."[21] It may be impracticable, however, for a space campaign to achieve undisputed command. Like the sea, air, and cyber domains, space cannot be conquered and occupied. Given various environmental, technical, and resource constraints, it may only be practicable to maintain control as a localized or periodic condition.

Despite little space combat experience, it appears there is a first-mover advantage, and the offense is the stronger form of warfare in space (at least in orbits near Earth) as it is at sea and in the air. Indeed, it likely will be difficult to secure control of LEO for long in a major conflict. If it is more tactically and technically feasible to deny freedom of action, the space campaign may result in "disputed control." In conditions where command cannot be secured, as Sir Julian Corbett explained, it is possible to "prevent the enemy either securing or exercising control for the objects he has in his view."[22]

In practice, space control is unlikely to be a condition wherein U.S. and friendly forces operate without any harassment or the adversary is completely prevented from utilizing space. As Mahan wrote, "the control of the sea, however real, does not imply that an enemy's single ships or small squadron cannot steal out of port, cannot cross more or less frequent tracks of ocean, make harassing descents upon unprotected points of a long coastline, enter blockaded harbors."[23] Since it is prudent to anticipate that control may be disputed, a key question that must be addressed to design sufficiently resilient, protected, and defended forces is how much control is required to achieve mission success?

Given its geographic location, need for global power projection, and reliance upon space systems to help overcome spatial and temporal disadvantages, the U.S. must be able to assure freedom of action for critical missions that cannot be performed by terrestrial alternatives. Moreover, America must have the means to deny enemy use of space for such hostile purposes as targeting, command and control, and weapons delivery. The U.S. does not necessarily require the ability to "sweep the skies" clear of all enemy satellites, but it must be able to hold them at risk of prompt neutralization and interdict reconstitution for pre- and intra-war deterrence, force protection, and operations security. A condition of reciprocal denial, wherein neither side can exploit the domain, would be disadvantageous to the U.S. if the adversary is less dependent upon space for warfighting.

America probably does not need undisputed command to utilize the domain to increase the combat effectiveness of joint and combined forces. As Captain S.W. Roskill said regarding maritime strategy, the objective "is not so much to establish complete control of all sea communications, which would be an ideal hardly attainable until final victory was almost won, as to develop the ability to establish zones of maritime control wherever and whenever they may be necessary for the prosecution of the war in accordance with the directions of the Government. And a zone of maritime control means no more than an ability to pass ships safely across an area or water which may be quite small in extent or may cover thousands of square miles of ocean."[24] During World War II, allied sea and air power demonstrated that "working control" which assures sufficient freedom of passage can provide military advantage.

Future space forces must have enough resilience, protection, defense, and offense to achieve working control of lines of communications and orbits wherever and whenever necessary to achieve mission success. Force structure and posture must be designed for the full range of plausible contingencies. This includes "grey zone," clandestine and covert operations, "cheap shots" to undermine socio-economic or combat effectiveness, surprise and attrition of critical assets in deep crisis, sudden threat surges against strategic assets early in hostilities, a multi-weapon space control campaign during regional war, and nuclear escalation in major regional or global conflict.

In the context of the space control campaign, forces must be prepared for enemy action including: space-oriented deception, influence, information, and false flag operations; sabotage of supply chains, critical infrastructures, and computer networks; interference with sensors and communications links; rapid asset deployments and maneuvers; close trailing, uncooperative rendezvous and proximity operations; piracy of signals and spacecraft; mining and blockades of launch corridors, antipodal, transfer, crossing, Lagrange, or other choke points; armed-reconnaissance; raids against terrestrial or orbital system segments; interdiction of communications lines and logistics; ambushes with concealed weapons on-orbit; diversionary attacks; preemptive decapitation strikes; and shock assaults and swarming with multiple terrestrial and space-based weapons. Planners can look to military history to learn its lessons, avoid a failure of imagination, and prevent surprise.

The space environment and physics of spaceflight will influence international relations and warfare just as Earth's physical, human, and political geography does. The vastness of space is an important domain characteristic and, while there is no "terrain" per se and sparse human habitation, there are weather, radiation belts, gravitational differences, and other factors that make certain orbits more favorable than others. Space has unlimited operational depth and no political boundaries. Forces in Earth orbit provide a unique vantage point overseeing the planet and can flank terrestrial battlefields. Indeed, space provides a commanding position from which to influence hostilities given the challenge of attacking up Earth's gravity well.

Moreover, geopolitical competition is extending to Cislunar space and the Moon, giving new meaning to the domain as the ultimate high ground and a theater or operations. This will have significant implications for force design and war planning. In the future, a contest over Cislunar space, including Lagrange points, could dominate the course and outcome of conflict for control of the Earth-Moon system. Within this broader strategic-political and operation-level context, decision-makers must determine how to apply technology and employ tactics to provide awareness, mitigate vulnerabilities, and incorporate the right mix of resilience, protection, defense, and offense to achieve mission success.

Tactical-Technical Considerations

While numerous factors bear upon the technical design and tactical employment of space forces, system design and technology typically shape tactical choices. Specific missions and requirements in conjunction with the laws of physics and economics drive system design as well as approaches to resilience, protection, and defense. Despite the preponderance of debate over tactical-technical matters, the desire for simplistic solutions to a complex, multidimensional problem has produced questionable assertions hindering deliberations. One example is that the U.S. should eschew space solutions and instead reallocate resources for terrestrial alternatives. While those could enhance robustness, redundancy, and provide backups or workarounds, there is no such thing as an invulnerable tank, ship, plane, computer, or satellite. Despite their vulnerabilities, all have military utility for deterrence and warfighting.

The question is not whether an individual spacecraft is survivable or resilient, it is whether the space-reliant elements of a multifaceted, all domain force can perform when necessary to execute the mission. Pursuing inherently resilient architectures or impregnable defenses is futile. Some design approaches offer more intrinsic resilience against certain threats than others, just as some defenses are more effective than others. Instead, the objective should be sufficiently resilient, protected, and defended mission capabilities to evade, operate through, degrade gracefully, and prevent attack. While each force structure element poses different opportunities and challenges for attack and protection, the overall design will only be as strong as the weakest link or node in the context of specific threats and countermeasures. A holistic approach that evaluates alternatives end-to-end across domains thus is essential.

Another example is the assertion that disaggregation is the best approach to increase resilience. Besides aggregation and disaggregation, options include proliferation, distribution, and diversification (using different types of assets to perform the mission) as well as hybrids that combine two or more approaches. Determining the best design solution requires understanding trades among capability, affordability, resilience, protection, and defense. The trade space should include evolving current programs, acquiring new systems, leveraging commercial and international capabilities, alternative mission designs and orbits, passive and active countermeasures, and terrestrial alternatives.

All approaches have strengths and weaknesses. While threats to aggregated designs can be mitigated with sufficient protection and defense, aggregation will not be resilient if small numbers of capital assets in constellations can be overwhelmed by the offense. Aside from enabling proliferation, separating nuclear and non-nuclear missions onto different platforms by itself would do little to enhance resilience.

Instead, proliferation, distribution, and diversification (including multidomain integration) provide the best levers to enhance resilience against some threats. Some degree of proliferation is a prerequisite for distribution. The resilience value of proliferation is a function of cost-exchange ratio, the adversary's targeting capability, attack method, probability of kill, magazine depth, and ability to execute large numbers of successful attacks. While proliferation may enhance resilience against certain kinetic threats to the orbital segment, just adding more assets will not necessarily increase resilience against cyber-attacks, electronic warfare, directed energy, or nuclear weapons effects without additional countermeasures.

Distributing value across orbits, spectrum, hosts, and geography would strengthen resilience by increasing targeting difficulty, complicating an adversary's risk calculus, and enabling graceful degradation. Asset diversity, autonomy, and multipath communications would make individual satellites less attractive targets. Leveraging commercial and international capabilities would contribute to diversifying assets and communications paths. In addition, multi-domain integration (for example, space-air-cyber) for distribution and diversification is a resilience lever for regional/local missions but may be inefficient on a global scale. The extent of integration (from augmentation on one end of the spectrum to interdependence on the other) with terrestrial, commercial, or international alternatives is a choice with both opportunities and risks. The ability to dynamically employ and maneuver such assets is a key to deriving operational utility from their added capacity and robustness.

Concentrating on the orbital segment rather than the entire system or mission design (including enabling capabilities such as awareness, command and control, and logistics) is another diversion in the debate. If the weakest link or single node failure is in the terrestrial or cyber domains, the enemy could bypass the orbital segment. Since satellite systems operate in multiple domains, space warfare will likely be a cross-domain fight.

Similarly, spacecraft size is a source of distraction. Contrary to the simplistic notion of "large, juicy targets," size is not the key determinant of how easily an adversary can engage a satellite. Targeting depends upon the quality and quantity of an adversary's intelligence and space object surveillance and identification support for offensive counterspace operations as well as the sophistication of its command and control. In fact, radar cross section, visual magnitude, and radiofrequency, thermal, or other emissions, likely are more relevant to targeting than size.[25] In addition, satellite bus size, weight, and power (SWAP) are driven by mission payload(s) and other subsystem demands. Technological advances, particularly electronics miniaturization, are leveraged in all spacecraft sizes. While this increases the performance of smaller platforms, vulnerability mitigation requires onboard countermeasures such as auxiliary payloads and/or fuel for threat avoidance maneuvers impacting SWAP and cost.

Orbit selection, such as the current emphasis on PLEO, is also clouding debate. There are numerous potential orbits (trajectories around the Earth, other celestial objects, or through space based on gravity). Their relative merits are mission and technology dependent. While the location of spacecraft is predicable because physics governs their motion, there are operational advantages and disadvantages of different orbital regimes. Some missions must be performed at certain orbits because of physics or technological state-of-the-art. While some orbits currently face fewer threats than others, that is likely to change as valuable assets are deployed there.

Time, distance, and speed will matter in space just as they do in other domains. The amount of time to deliver effects or respond with countermeasures is largely driven by distance and threat. More threats to spacecraft are currently based on Earth than in space. A satellite thus is susceptible to more threats the closer it is to Earth. It will be vulnerable if an adversary is aware of and can exploit the susceptibility. Consequently, satellites in LEO may be at greater risk than those in other orbits.

A space mission or system will only be as resilient as its weakest link or node because that is what a competent adversary will target. Measures to counter all threats to all links and nodes thus are required for resilience, protection, and defense. There is a broad array of such measures. While some may be technically infeasible or prohibitively expensive, the U.S. has the operational experience and industrial competence to create the space force structure and posture required to protect and advance its interests. There is a rich cache of analyses to draw upon from the last time America thought seriously about space warfare – late in the Cold War after President Reagan initiated the Strategic Defense Initiative. Designs should be based on rigorous, data-driven, systems engineering, operations, and economic analyses enabled by physics-based modeling and simulation to optimize force structure and posture.

Combinations of passive and active measures should be integrated into a layered, dynamic, defense-in-depth to enhance deterrence, resilience, protection, and defense. Passive countermeasures are necessary for protection but may be insufficient to address certain threats. Some threats must be suppressed or destroyed by active defenses. Like carrier battle group defense, integrated air defense, or ballistic missile defense, such an approach aims to thwart an attack with successive layers and multiple countermeasures at each layer to defeat threat kill chains, rather than relying on a single line of defense. It can mitigate vulnerabilities, reduce risks, complicate enemy planning and targeting, and protect critical assets with capabilities deployed in mutually supportive positions and synergistic roles. Passive and active defenses will work if they limit damage, delay, or disrupt an attack or compel the adversary to expend a disproportionate amount of scarce resources to execute it. Defenses should be implemented for the classic purpose of complementing the offense in the overall joint or combined force design for deterrence and warfighting.

Conclusion

Future space forces must be designed to provide the military power necessary to protect and advance U.S. national interests. Space forces must be able to deter, fight, and win against a broad range of adversaries, threats, and contingencies across the conflict spectrum. They must be able to carry out missions, functions, and tasks for operations other than war, multi-modal warfighting, and ensuring the nation's survival under the most stressing wartime circumstances. Consequently, their size, capability mix, disposition, and readiness must be driven by the exigencies of geopolitical competition and imperative to counter the threat or use of force in space.

To be effective instruments of statecraft and warfare, space forces must deliver the capabilities and effects necessary for deterrence, escalation control, and warfighting. The answer to the question of how much space power (including its resilience, protection, defense, and lethality) is enough is driven by U.S. interests and policy objectives. The U.S. national security establishment thus must expand the focus of deliberations about force design beyond narrow tactical-technical considerations while concurrently reexamining some of the questionable assertions made at that level of debate. Efforts to redesign forces to provide the space power required to be an effective instrument will continue to be hindered until a sounder intellectual basis is established that addresses essential strategic-political and operation-level considerations.

This includes cogent policy guidance on the use of force in space for self-defense, deployment and employment authorities, and targeting and defensive priorities.

While the United States will not necessarily require space forces to establish undisputed command of space in wartime, it must have sufficiently resilient, protected, defended, and lethal capabilities to seize and maintain working control over key orbits and lines of communication, including Cislunar space as competition extends there. This requires a force structure and posture that can counter multiple vectors of coercion, ensure access and use of space for logistics and power projection with a layered, dynamic, defense-in-depth, win the information operations, cyber, and electronic warfare fight to and in space, and strike quickly and effectively to deny hostile use of the domain.

Space forces must be able to conduct prompt and sustained combat, combat support, and combat service support operations necessary to execute U.S. defense strategy and military doctrine. Combat involves space control and force projection to influence the course and outcome of war. Combat support includes intelligence, surveillance and reconnaissance, space domain awareness, command, control and communications, positioning, navigation and timing, and environmental monitoring to improve the effectiveness of military forces and support other intelligence, civil, and commercial users. Combat service support includes logistics to deploy and sustain military and intelligence systems in space.

Space forces should be structured to provide force packages of capabilities with readiness levels commensurate with their mission and the threat. Their size and strength should be geared for the stressing demands of achieving mission success in contested, degraded, or operationally limited conditions against multiple nuclear-armed great powers with regional allies or proxies. To tailor forces for operations across the conflict spectrum, their structure should be designed to provide at least three capability tiers based on mission criticality and impact of loss, incapacitation, or disruption: (1) highly survivable, enduring, protected, and defended capabilities essential for national survival; (2) protected and defended capabilities essential for warfighting; and (3) secure but less protected and resilient capabilities for other military missions.

The posture and disposition of space forces should complicate an adversary's risk calculus, present a very difficult targeting challenge, and enable forces to evade, operate through, degrade gracefully, and prevent attack. There is no simple resilience, protection, or defense solution given the scope and intensity of threats. Nor is there a single best orbit, spacecraft size, or mission and system design. Consequently, the most prudent approach is a hybrid design that proliferates the number of assets in constellations and overall mission capabilities, diversifies the mix of dedicated national security and contributing commercial and international assets, orbital regimes, spacecraft sizes, passive and active countermeasures, and communications paths, and distributes mission value across orbits, spectrum, hosts, and geography. Although most space force assets should be acknowledged for shaping, deterrence, and reassurance, selected capabilities should be concealed until necessary to employ them for surprise, escalation control, and operational advantage.

While the nature of war is enduring, its character is constantly changing as new technology and operational concepts are introduced. The exigencies of the geopolitical competition and modern warfare demand that America harness technological innovation in the design and operation of space forces. The United States must win the competition for development and application of advanced technology to sustain its strategic advantages in space. Future forces must have the flexibility and agility to implement rapidly new concepts and tactics enabled by such emerging technology as artificial intelligence, quantum computing, in space servicing, assembly, and manufacturing, and directed energy. Rather than looking in the rear-view mirror and preparing for past wars or searching for simplistic solutions to hard problems, force designers must look forward to the prospective character of future warfare in space.

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[15] Kevin Chilton, "Empower our Space Force, just as we do for the other armed services," Defense News, January 28, 2022.

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