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FROM SANCTUARY TO BATTLEFIELD:

A Framework for a U.S. Defense and Deterrence Strategy for Space

Elbridge Colby

Center for a New American Security

ABOUT THE AUTHOR

Elbridge Colby is the Robert M. Gates Senior Fellow at the Center for a New American Security (CNAS). Previously he served for over five years in the U.S. government, primarily in positions focusing on nuclear weapons, arms control, and intelligence reform. He has also served as a staff member or advisor to several governmental commissions, including the 2009 Congressional Strategic Posture Commission and the 2014 National Defense Panel, and serves as a consultant to a variety of U.S. government entities on a range of defense and intelligence matters. He has published book chapters in a number of edited collections and writes regularly on defense and foreign policy issues in a variety of venues such as *The New York Times, The Wall Street Journal, The National Interest*, and *Foreign Policy.* He speaks frequently to government, expert, university, and broader public audiences both in the United States and abroad.

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TABLE OF CONTENTS

Glossary of Terms [1]	
ASAT	Anti-satellite weapon.
C4ISR	Command, control, communications, computers, and intelligence, surveillance, and reconnaissance.
Dazzling	The use of intense directed radiation to temporarily blind a target's sensors.
Endoatmospheric	Operating within the lower atmosphere, or atmosphere proper, which extends to around 60 miles above the Earth's surface.
Exoatmospheric	Operating beyond the lower atmosphere, or atmosphere proper.
Geostationary equatorial orbit (GEO)	A geosynchronous orbit tracking directly over the Earth's equator. In GEO, the satellite will generally remain directly over the same place on the Earth's surface.
Geosynchronous orbit (GSO)	A circular, high Earth orbit in which a satellite's orbital speed matches the Earth's speed of rotation. Since the satellite is orbiting at the same rate that the Earth is turning, it appears to stay in place over a single longitude, although it may shift north to south.
Jamming	The deliberate radiation, reradiation, or reflection of electromagnetic energy in order to prevent or reduce an enemy's ability to use the electromagnetic spectrum.
Lasing	The use of a laser. In the case of satellites, lasing can be used to damage or disrupt a satellite's sensors by "blinding" or "dazzling" them.
Low Earth orbit (LEO)	The orbit closest to the Earth's surface, where most scientific and many weather satellites operate.
Medium Earth orbit (MEO)	The region of space above low Earth orbit and below geosynchronous orbit.
Orbital debris	Any man-made object in orbit around the Earth that no longer serves a useful function. Orbital debris includes non-functional spacecraft, abandoned launch vehicle stages, mission-related debris, and fragmentation debris.
PNT	Positioning, navigation, and timing.
SSA	Space situational awareness.

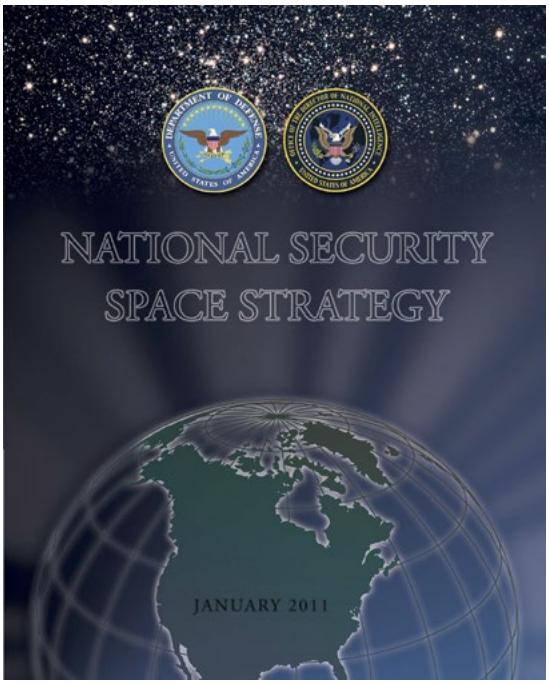
I. The Vital Importance of Space to the United States – and the Increasing Threat

The United States is profoundly reliant on the ability to use space for its security. Though little appreciated outside of professional and expert circles, space – or, more precisely, U.S. assets in and using space – are vital to U.S. defense and intelligence communications with and among national leaders, military forces, and others; command and control; positioning, navigation, and timing (PNT); intelligence, surveillance, and reconnaissance (ISR); and a host of other functions. While these may seem rather like "back office" functions to a lay reader, they are actually the stuff of which American global military primacy is made. The U.S. military is not currently superior to its potential adversaries because it has stronger soldiers, bigger guns, or more tanks. Rather, it has the upper hand because it can understand better what is taking place in the midst of conflict, what its own forces are doing, and what those of an enemy are doing amidst the "fog of war."[2] The United States can therefore employ force around the globe more rapidly, more precisely, and more intelligently – and thus more effectively.[3] Together, this "smarter" and more agile U.S. military is therefore uniquely capable of applying decisive power against an adversary.[4]

Exploitation of space is particularly critical to effective U.S. power projection, as it provides the U.S. military with the ability to operate effectively over global distances, beyond the reach of what U.S. ground-based and aerial assets, limited by range and endurance, can provide. As General John Hyten, Commander of U.S. Air Force Space Command, recently said on CBS' *60 Minutes*, because of space "we can attack any target on the planet, anytime, anywhere, in any weather."[5] Thus Washington's ability to project credible and effective military power to key regions such as the Western Pacific, Europe, and the Middle East – which is elemental to the U.S. national security strategy of forward engagement – relies on space. And this reliance is increasing.

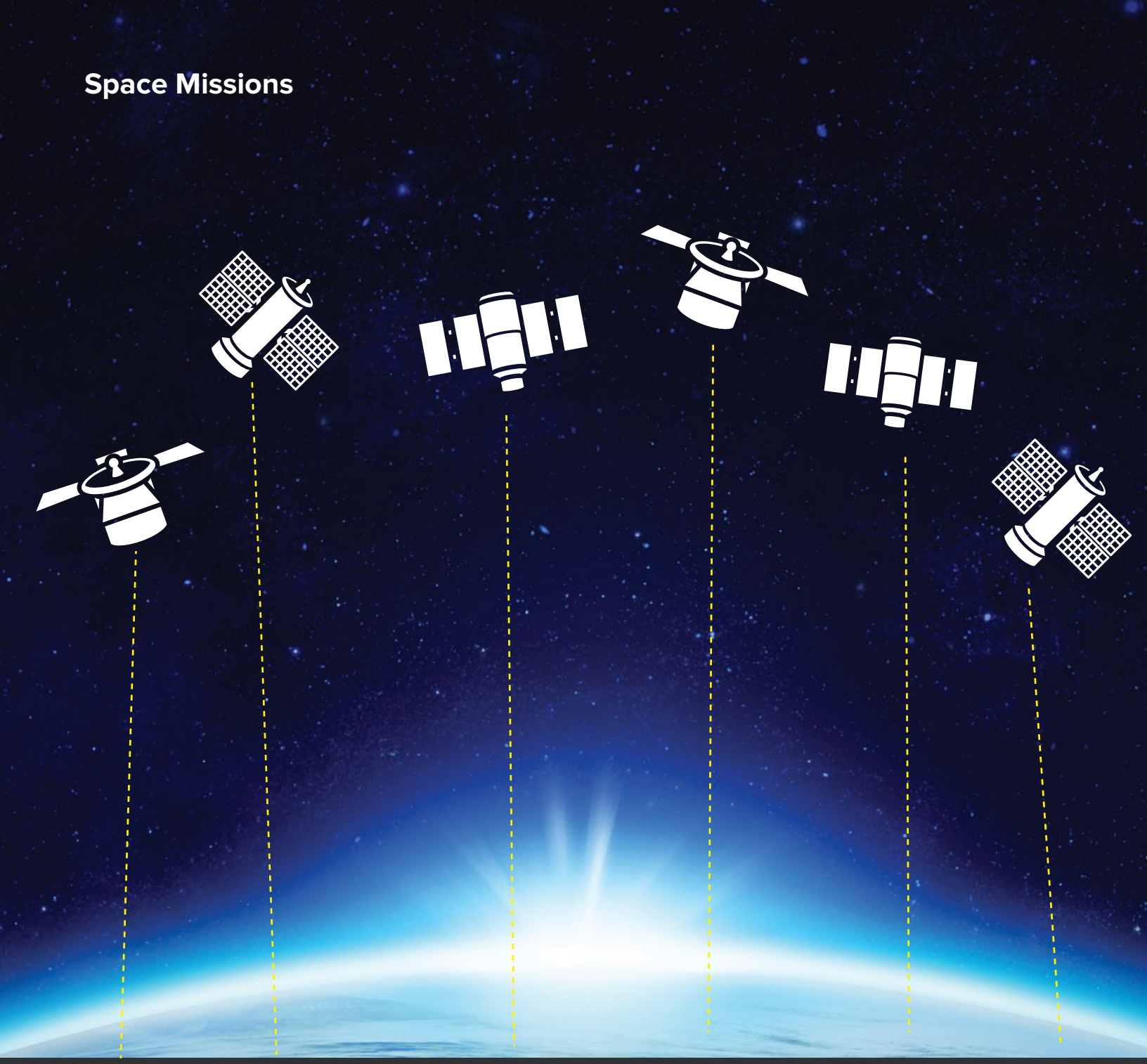
Furthermore, while space is crucial for U.S. power projection and an effective military posture in key regions, it is also vital for crucial homeland defense and deterrence functions. Space-based assets provide early warning of missile attacks against the United States (and others) and serve as a crucial component in the command and control system for U.S. nuclear forces in the event of war – including a nuclear war.[6] As the 2011 U.S. *National Security Space Strategy*, a document bearing the signatures of the Secretary of Defense and the Director of National Intelligence, summarized, "[s]pace capabilities provide the United States and our allies unprecedented advantages ... create a decision advantage ... [and are] vital to monitoring strategic and military developments ... Maintaining the benefits afforded to the United States by space is central to our national security."[7]

Space, then, is vital for America's military preeminence and the national strategy it underwrites. But this reliance is becoming increasingly problematic. This is because potential U.S. adversaries have noticed the degree of U.S. reliance on its space architecture and the advantages that the United States has accrued from it and have been



The National Security Space Strategy, the Obama Administration's flagship policy statement on national security space issues, was jointly released in January 2011 by the Secretary of Defense and the Director of National Intelligence.

Space Missions



EARLY WARNING

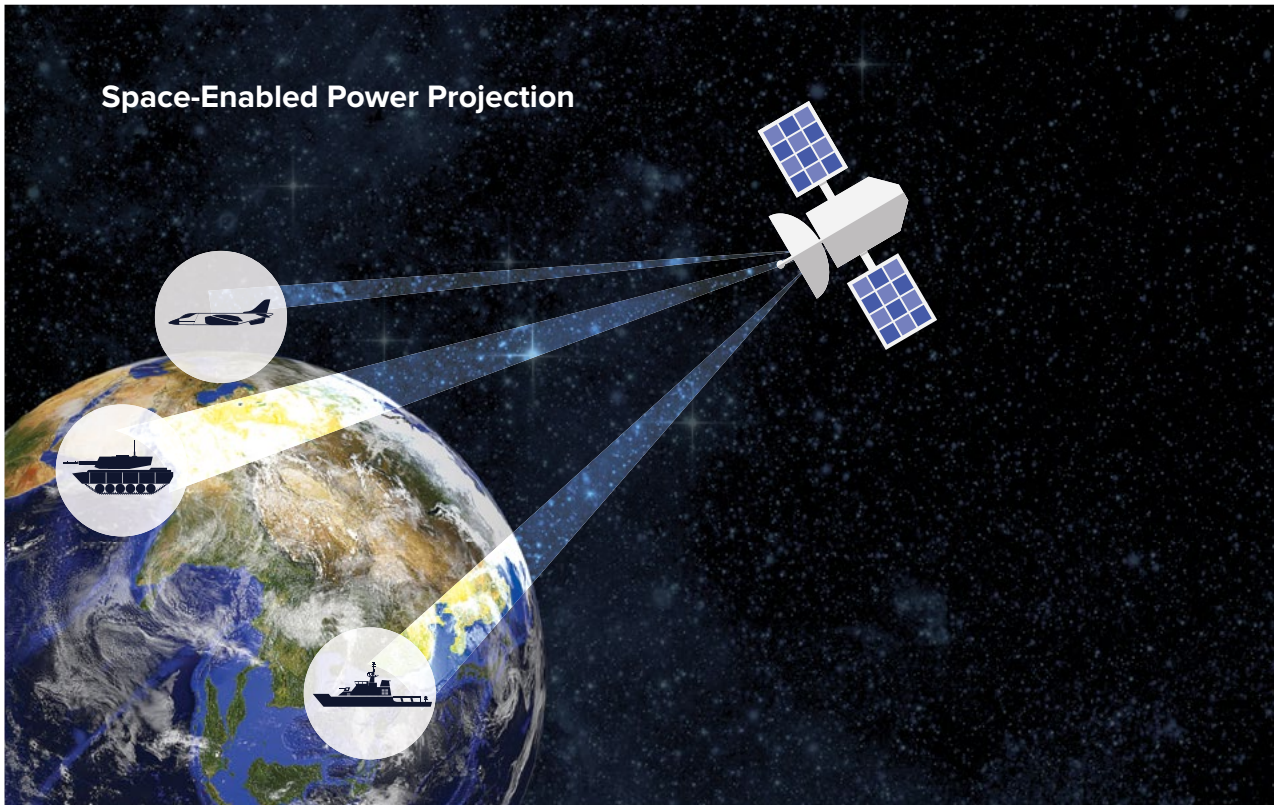
INTELLIGENCE, SURVEILLANCE & RECONNAISSANCE

POSITIONING, NAVIGATION & TIMING

COMMUNICATIONS

COMMAND & CONTROL

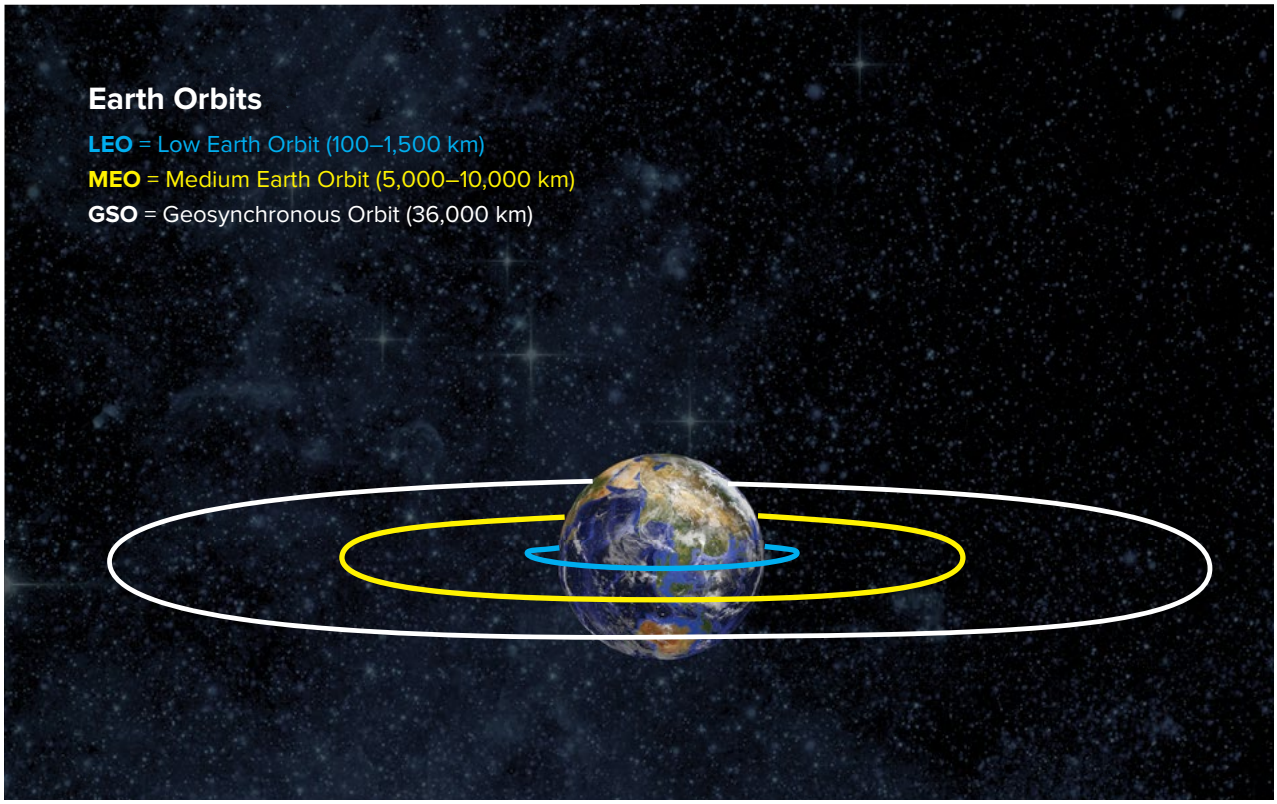
WEATHER



assiduously working to find ways to threaten U.S. space and space-related systems. Indeed, many observers have noted that these potential opponents judge the U.S. space architecture to be the "Achilles' heel" of U.S. military power, in light of the depth of American reliance on these systems and the vulnerability of the U.S. satellite architecture.[8] As General Hyten put it, without access to space the U.S. military would be a greatly reduced force. As he put it, in such a circumstance the U.S. military would return to a model of "World War II" or "industrial age" warfare.[9]

Nor is this merely a peril for the future. Rather, after many years in which this problem seemed safely ensconced over a distant horizon, it is now coming increasingly into view that threats to U.S. space assets are real and pressing – and indeed are likely to worsen, probably significantly.[10] Countries like Russia, China, and even nations with more modest capabilities and resources are gaining the ability to hold U.S. satellites at risk not only through kinetic direct-attack methods such as anti-satellite (ASAT) missiles, but also through non-kinetic and more limitable techniques such as jamming, "dazzling," cyber and other electronic attack, and other novel methods.[11] Some of these approaches can destroy or disable satellites, whereas others offer the option of blinding or otherwise interfering with the effective functioning of space assets.[12]

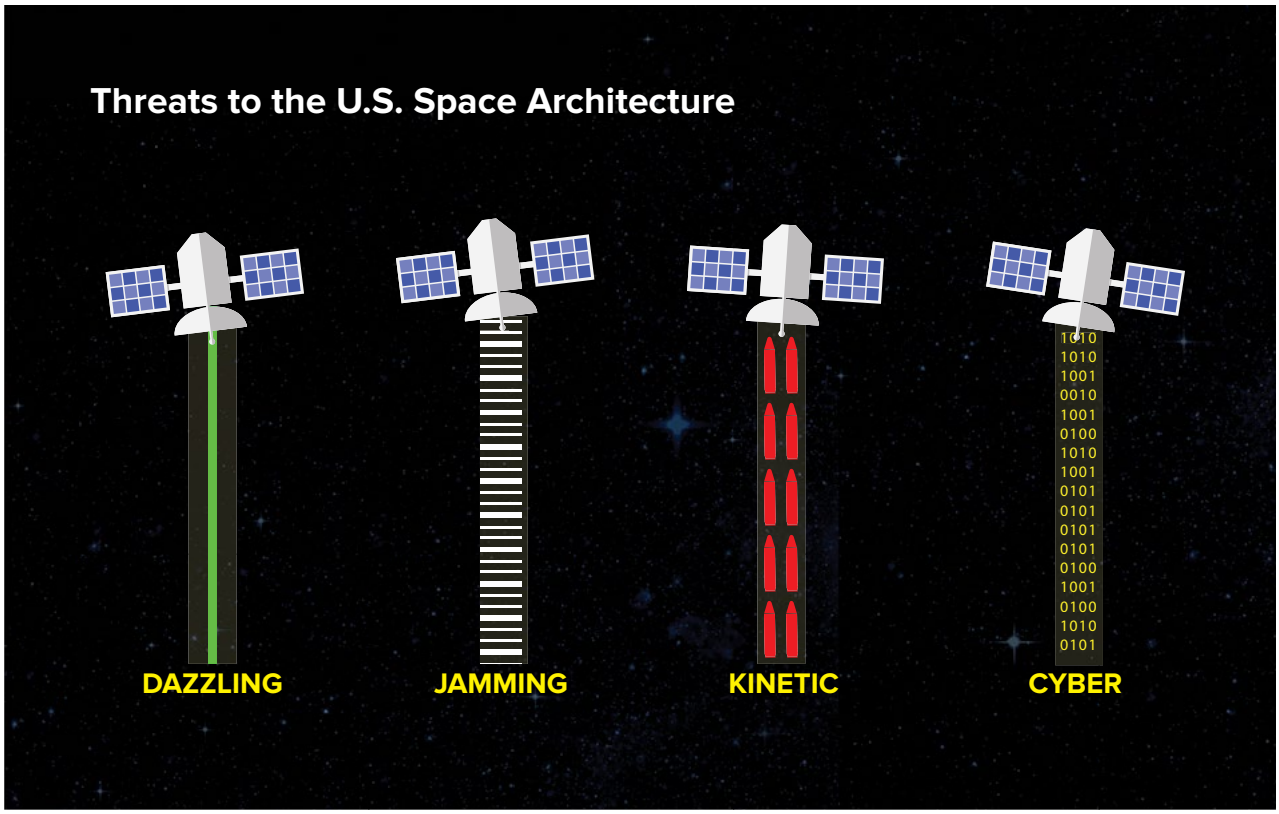
The result is that the U.S. space architecture is becoming increasingly vulnerable, with U.S. satellites in low Earth orbit already targetable by a nation such as China and with U.S. satellites in deeper space very likely to become similarly exposed soon.[13] China's 2007 destruction of a satellite in low Earth orbit demonstrated its ability to hit satellites at that range.[14] And its 2013 test of an anti-satellite weapon reportedly propelled a missile approximately 18,600 miles into space, just shy of the 22,236 miles at which U.S. satellites in geosynchronous orbit – including essential missile warning and communications satellites – are located.[15] As Air Force Lieutenant General John Raymond, then the Commander of the 14th



Air Force and the Joint Functional Component Command for Space for Strategic Command, testified in March 2015: "We are quickly approaching the point where every satellite in every orbit can be threatened."[16] In sum, then, the United States is highly reliant on its space architecture for the full range of military operations – and that architecture is vulnerable and becoming more so.

The commitment and cunning of potential adversaries is not the only or even necessarily the primary source of official concern. Rather, a great deal of the pessimism about the future security of the U.S. space architecture derives from the reality that the existing U.S. space architecture is vulnerable and delicate because it was not designed to deal with the kinds and degree of threats that are emerging. To the contrary, U.S. space assets have historically been built and postured in ways that largely presumed their safety or sanctuary from attack. As the then-commander of U.S. space forces, General William Shelton, put it in 2014: "Our satellites were not built with such threats in mind. In fact, space largely has been a peaceful sanctuary up to this point, and due to the cost of each of these intricate machines we build just enough capability and build it just in time."[17]

This relative neglect was not a product of malign intent or foolishness. Rather, past decisionmakers had reasons (some better than others, and some more justifiable at different times than others) for deciding to build the U.S. space architecture in this way. For one thing, U.S. space assets enjoyed a degree of sanctuary for many years due to the significant technical challenges to being able to strike at or interfere with satellites. This meant that investments in defending space assets often seemed unnecessary and wasteful, especially in the face of the immense costs of space lift and the incentives to concentrate multiple payloads on a single platform. Particularly in the permissive post-Cold War security environment, space decisionmakers thus elected to err in favor of efficiency, streamlining, and eliminating redundancy, thereby maximizing performance (in much the same way



that the United States streamlined its basing infrastructure in the Pacific in ways that have made it more vulnerable to Chinese attack).[18]

Moreover, through the Cold War the main threat to U.S. satellites was judged to be a nuclear attack, one that was thought would signal the prelude to or be a component of a general strategic attack by the Soviet Union. In large part for this reason, during the Cold War attacks on space assets came to take on a connotation of total war, of a desire to cross the fundamental boundary demarcating a limited conflict from a general war between the superpowers.[19] There was thus reason to think that, even to the degree that the U.S. space architecture was vulnerable, a capable adversary like the USSR would still be loath to attack it.

There were thus reasons, many of them justifiable, for the United States to build its space posture in the way it did. But the upshot of these factors has been to leave the U.S. space force vulnerable – and increasingly so as adversaries exploit new technologies to hold these assets at risk. The United States has therefore built an enormously expensive and delicate architecture of space assets upon which it greatly relies for its military preeminence – and left it increasingly vulnerable to adversary attack or disablement. As some have put it, the past history of U.S. space procurement and policy has left the U.S. satellite architecture replete with "juicy targets."[20] Or, as the former head of Air Force Space Command put it, space had "been kind of [a] peaceful sanctuary. It is not anymore."[21]

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II. The U.S. Response to the Threat Thus Far

This is the problem. The question now is what is to be done about it. And, more specifically, what can be done to deal with it in a sustainable way that continues to maintain the U.S. ability to hold the military-technological high ground over plausible adversaries like Russia and China, meaning in particular the ability to exploit the use of space in the service of overall U.S. military superiority.

Fortunately, the United States and the Department of Defense (DoD) in particular are increasingly seized with this problem and calling on the policy world and industry to help respond to it.[22] This represents an improvement. As recently as 2011, the U.S. government took a rather measured tone on the dangers to the U.S. space architecture. In that year, the *National Security Space Strategy* observed rather sanguinely that the "evolving strategic environment increasingly challenges U.S. space advantages" and that "[s]pace … is becoming increasingly congested, contested, and competitive."[23] Now, however, DoD and, to some extent, the U.S. government as a whole have taken on a noticeably more alarmed tone about the scale and intensity of the threat to the U.S. position in space. At the early 2015 annual threat testimony of the nation's intelligence chiefs, both Director of National Intelligence James Clapper and Director of the Defense Intelligence Agency Vincent Stewart drew attention to the growing challenge to U.S. space assets, with Clapper observing that "[t]hreats to U.S. space systems and services will increase in 2015 and beyond," particularly from China and Russia.[24] More pointedly, Under Secretary of Defense Frank Kendall, the Pentagon official responsible for weapons acquisition and development, reported in March 2015 that the American position in space "is particularly bad" due especially to Chinese and Russian advances in anti-space capabilities. In fact, Kendall publicly assessed that the threat to the U.S. posture in space by 2025 would in fact be the most severe among all the military domains – a more serious vulnerability for the Pentagon, in other words, than the growing threats to U.S. surface ships or bases or the perils to the U.S. military in cyberspace, each the subject of a much greater amount of recent public attention.[25]

Nor has the Pentagon's growing anxiety only been manifested in words. In perhaps the most revealing reflection of the DoD's increased anxiety about the U.S. position in space, the Pentagon recently established an initiative to invest as much as $8 billion more in space capabilities over the next five years, an especially serious signal of how gravely the Pentagon takes the problem in light of how precious such funds are since the enactment of the Budget Control Act of 2011.[26] The Pentagon official with primary responsibility for space explained this increase as reflecting "a far more serious commitment to the mission area, reflective of what we see in the threat."[27] Even the 2015 *National Security Strategy* sounded the alarm about the aborning challenges to U.S. interests in space.[28]

U.S. Navy

A modified SM-3 missile launches from the missile cruiser the USS Lake Erie *in 2008 to intercept a dysfunctional American satellite.*

As a consequence of this shift, the DoD's bureaucratic and procurement wheels have begun to move, albeit very slowly. The Pentagon is undertaking or has undertaken a number of internal reviews on how to chart the course for the future U.S. space architecture.[29] The Department of Defense is making its new satellites more maneuverable to evade attack and rendering them more resistant to jamming while also building a new radar system that will better enable it to track objects in space, which will aid in gaining for the United States a better sense of the space threat. The United States has also deployed two space surveillance satellites to observe what other countries are doing in geostationary orbit.[30] Looking forward, the Air Force has also urged DoD to undertake revolutionary and disruptive changes to its space procurement, research and development, and posture.[31]

While these steps represent encouraging progress, the reality, however, is that these changes will take time to bear fruit, not least because it has in recent years taken upwards of a decade to develop, build, and launch satellites. Moreover, even under ideal funding and policy conditions, the problem posed by threats to the U.S. space architecture is very unlikely to be fully "solved." The United States will need to continue to rely greatly on space, as it is simply too useful to be abandoned. And as the United States continues to do so, the systems it puts into orbit will still be essentially fragile, operating in a hostile environment that is by its nature difficult and expensive to access and operate within.[32] At the same time, the march of technology and its diffusion mean that space assets will likely become more rather than less vulnerable – great distance and the difficulties of precise targeting are no longer insuperable problems to a growing range of potential opponents.[33] As a result, the vulnerability of important space systems will be a reality to be recognized, managed, and dealt with rather than one to vainly attempt to eliminate.

In effect, then, space is becoming a domain like any other – air, sea, land, and electromagnetic – in which the United States will have to compete and fight for the ability to access and exploit the domain rather than assume safe and uncontested passage within and use of it.[34] The United States will therefore need to adapt to this emerging reality of persisting reliance on space coupled with growing vulnerability. The question is how best to do so.

Even under ideal funding and policy conditions, the problem posed by threats to the U.S. space architecture is very unlikely to be fully "solved."

III. Candidate Approaches for Dealing with the Threat to the U.S. Space Architecture

One obvious way to address the growing threat to the U.S. space architecture is to seek to defend against it. Improving the defenses (active and passive) of U.S. space and terrestrial assets, for instance, offers a clear avenue to diminishing the vulnerability of the architecture.[35] Defenses for assets in space can be augmented, for instance, by increasing the hardiness of the satellites themselves to enable them to defeat, survive, or ride out attack; by providing future satellites with upgraded active defenses of their own; by deploying additional, dedicated systems to guard satellites and their associated architectures (for instance interceptor systems); and by improving space situational awareness (SSA) to better anticipate and understand threats.[36] Alternatively, the threat can be negated or minimized through the development of strike capabilities for use against adversary anti-space assets. These could include kinetic and non-kinetic capabilities to attack adversary anti-space missiles and non-kinetic weapons/tools as well as the command, control, communications, computers, and intelligence, surveillance, and reconnaissance (C4ISR) architecture needed to guide and control them.

The problems with this defensive approach lie in the formidable cost and technological difficulties of providing direct defense capabilities for satellites, the inherent fragility of space assets and consequent challenges and limits to increasing their survivability, the tradeoffs involved in orienting satellites to defense rather than their primary missions, and ultimately in the broader disadvantages facing the defender in space. Given the punishing conditions of space, the delicacy of satellites, and other such factors, the demands and pressures on the defender are generally higher than on the attacker. Satellites carrying payloads weigh a considerable amount and thus require more propellant to move and specifically to evade the small and thus much more nimble and maneuverable ASAT warheads used to target them. Jammers and lasers, meanwhile, that can blind or disable satellites are relatively cheap compared to the defenses required to guard against them. Furthermore, defenses can produce self-defeating consequences of their own, such as orbital debris, that can end up crippling or negating the value of the satellite.[37]

Accordingly, the job of attackers is, generally speaking, going to be easier than the defender's, and considerably less expensive. Thus relying excessively, let alone exclusively, on defenses would likely put the United States in a losing cost-technological competition with potential adversaries, which would likely be able to circumvent at least a substantial portion of U.S. defenses in a cost-efficient manner.[38]

The problem with relying too much on developing capabilities against adversary ASAT capabilities, their associated terrestrial infrastructure, and the C4ISR networks that enable these weapons is that in many cases it is very and in some cases extremely difficult to develop, field, and employ capabilities (kinetic and non-kinetic) that can reliably preempt or interdict a sufficient portion of an enemy's anti-space capabilities. This stems from the fact that such systems – for instance missile systems, jammers, or lasers – may not always be readily identifiable or discernible; may be mobile, hardened, or concealed and thus hard to confidently target and destroy or disable; may not be targetable in time; and may be too expensive to pursue. Furthermore, reliance on preemption to defend crucial U.S. space assets would put the country in the position of needing to strike early or even first in a crisis or conflict at targets potentially deep within an adversary's territory (or even in a neutral third country), thereby generating serious stability and escalation concerns. A space defense strategy that relied excessively, let alone exclusively, on striking an adversary's counterspace assets preemptively could thus put the nation in an impossible political-military position, one in which it would be required to strike early in a crisis to ensure it could attack a potential adversary's counterspace architecture before they dispersed or readied their defenses. It seems clear that no American political leadership would want to be forced into such a position, and with ample reason.[39]

IMPROVE ACTIVE AND PASSIVE SATELLITE DEFENSES	
What would this entail?	**What are some of the challenges to this strategy?**
• Increase the hardiness of satellites; • Provide future satellites with upgraded active defenses; • Deploy additional, dedicated systems to guard satellites; and • Improve space situational awareness (SSA) to anticipate threats.	• Formidable cost and technological difficulties; • Inherent fragility of space assets; • Tradeoffs between orienting satellites toward defense capabilities vs. primary missions; • A punishing space environment puts the defense at an inherent disadvantage; and • Creates self-defeating consequences, such as orbital debris.
DEVELOP STRIKE CAPABILITIES	
What would this entail?	**What are some of the challenges to this strategy?**
• Preemptively strike at anti-space capabilities before they have the opportunity to attack; • Deploy kinetic and non-kinetic capabilities to strike anti-space missiles; and • Strike at command, control, communications, computers, and intelligence, surveillance, and reconnaissance (C4ISR) architecture needed to guide anti-space missiles.	• Difficulties in developing strike capabilities able to preempt a sufficient portion of anti-space capabilities, largely because enemy ASAT capabilities: » Are not readily identifiable or discernible; » May be mobile, hardened, or concealed; » May not be targetable in time; and » May be too expensive to pursue. • May force the United States into a position requiring an early first strike, which may or is likely to be unpalatable or inadvisable.
CHANGE COMPOSITION TO IMPROVE RESILIENCY	
What would this entail?	**What are some of the challenges to this strategy?**
• Disaggregate currently concentrated architecture into a larger number of smaller satellites; • Endow future space assets with greater maneuverability; • Improve SSA; • Develop future satellites that are more replaceable and expendable by making them more modular and adaptable; • Increase the redundancy of space assets to reduce points of vulnerability; • Streamline production to aid replacement; and • Improve space launch capabilities to ease getting new assets into orbit.	• Provides no disincentive to prevent an adversary from developing sufficient capabilities to overcome resilient systems; and • Adversaries will likely stay on the advantageous side of the cost competition due to the expense of launching and operating space assets.

REDUCE RELIANCE ON SPACE ASSETS	
What would this entail?	**What are some of the challenges to this strategy?**
• Prepare to use aircraft, unmanned aerial vehicles, and ground or sea lines of communications for functions currently performed by space assets (particularly communications relays and ISR missions;) • Develop more ground and sea-based communication links to lessen reliance on space assets; and • Prepare the U.S. military to operate in an environment with degraded C4ISR.	• A force content to operate without space assets will almost certainly be far less capable than one with them; and • Air-breathing ISR's effectiveness and reach are limited due to sovereignty concerns, air defenses, and other factors.
INCREASE INTERNATIONAL POLITICAL COSTS OF ANTI-SPACE STRIKES	
What would this entail?	**What are some of the challenges to this strategy?**
• Reinforce norms against anti-space attacks, particularly those that cause space debris; and • Associate U.S. national security payloads with foreign space assets to increase international and reputational costs of an anti-space attack.	• Different national strategic perspectives about the purposes and forms of arms control agreements make arms control treaties unlikely to succeed; • The United States is not likely to rely on shared multi-national space assets for core military missions; and • Shared multi-national space assets with a plausible allied country are not likely to provide sufficient dissuasion to prevent attack.

Another method for dealing with the increasing threat to the U.S. space architecture is to alter its overall composition to make it a less vulnerable target and to improve its resiliency in order to enable it to recover from damage. This would mean taking steps such as disaggregating the currently highly concentrated architecture into a larger number of smaller satellites; building more maneuverability into future space assets; improving SSA to better understand the space environment; developing future satellites that are more replaceable and thus expendable, for instance by making them more modular and adaptable; building more redundancy into the architecture as a whole to diminish points of vulnerability and failure; streamlining production processes to aid replacement; bettering the nation's space launch capabilities to ease getting new assets into orbit; and augmenting the ability of the United States to inspect, repair, and relocate its satellites on orbit.[40]

This approach is attractive and undoubtedly an important constituent part of any sensible space strategy as space becomes a more contested domain. Accordingly, the United States has begun to explore and pursue this avenue, fortified by the fact that the progress of technology offers opportunities for space resilience as well as for space offense.[41] As the advance of technology for spacefaring drives down costs and barriers to space activity, the United States can and should exploit these developments to develop a less vulnerable and more resilient space architecture.

The problem is that solely emphasizing resilience without credible ways of defending against or deterring adversary attacks courts failure, as alone it provides no meaningful disincentive to the adversary's simply taking the extra steps needed to attack this more resilient U.S. space architecture in detail. While this might be a more challenging and expensive proposition than striking at the current U.S. space architecture, the abiding vulnerability of space assets and the fundamental fact that launching and operating space assets will remain expensive mean that the adversary seems likely to stay on the advantageous side of the cost competition.

Solely emphasizing resilience without credible ways of defending against or deterring adversary attacks courts failure, as alone it provides no meaningful disincentive to the adversary's simply taking the extra steps needed to attack this more resilient U.S. space architecture in detail.

For instance, there are sharp limits to the advantages that adding maneuverability to U.S. space assets offers. Plausible additional maneuverability would not materially protect against the kind of homing ASATs that the Chinese and Russians have developed given the inherent advantages of a smaller, specialized projectile against a bulkier target satellite designed for other purposes and with limited propellant available. Indeed, even if such a satellite could outmaneuver a homing ASAT, the target satellite would have expended a large fraction – if not all – of its propellant and thus would not be able to return to its proper orbit.[42]

For these reasons, the Pentagon has already made clear that, while it will continue to emphasize resilience-promotion strategies like disaggregating functions onto a greater number of space assets, the United States will nonetheless need to pursue a broader approach to space in light of the limitations of this approach.[43] Added resilience will therefore be a necessary component, but it is unlikely to solve the fundamental challenges facing U.S. space strategy.

An additional avenue of approach for the United States is to seek to mitigate the consequences of its growing vulnerability in space by relying more on terrestrial and air-breathing assets for a range of missions that it has been relying on orbital assets to perform in recent years. For instance, the United States could prepare, especially in the event of conflict, to use aircraft, unmanned aerial vehicles, and ground or sea lines of communication for functions currently assigned to vulnerable space assets, such as communications relay, ISR,

U.S. Navy

A U.S. Navy communications satellite is launched into orbit from Cape Canaveral, Florida.

and the like. Along these lines, last year Secretary of Defense Carter called for the military to reduce its dependence on the increasingly vulnerable Global Positioning System (GPS) constellation.[44] Additionally, the United States could develop more ground and sea-based communication links to lessen reliance on space assets.[45] Relatedly, the U.S. military can prepare forces for operating in an environment of degraded or diminished C4ISR. In other words, U.S. forces can be trained or retrained to operate with more limited capabilities for functions such as PNT, or these functions could be insourced such that forces could operate more autonomously. In this vein, U.S. forces are already training for substantially reduced access to space services.[46]

This approach is also promising, and reports indicate that DoD is already looking at more endoatmospheric options for a variety of military tasks as well as preparing forces for operating in a less permissive C4ISR environment. But, while undoubtedly much can be achieved in these respects, the fact remains that a force content to operate without space assets would also almost certainly be a far less capable one than one able to leverage them – an "industrial" rather than an "information" and "space" age force, to use General Hyten's terminology. It seems difficult to imagine that the amount of data and the global reach of space assets can even be approximated by a terrestrial configuration and thus that forces operating without the benefits of space services could be remotely as effective as those that do. For instance, ground-based communications (such as fiber, microwave, and cellular communications) are satisfactory for fixed installations in relatively friendly territory, but cannot adequately support maneuver forces, particularly at the forward edge of the battle area. Meanwhile, airborne ISR and, possibly, communications relays may be more suitable but are limited by short line-of-sight restrictions, and most such platforms cannot operate in denied airspace, especially not

for long.[47] Moreover, even in non-hostile territory using air-breathing platforms for ISR or communications would likely often be problematic because their reach would be limited due to concerns about sovereignty, since the airspace above countries is part of their sovereign territory while space is not. In other words, while it certainly makes sense to reduce the dependence of U.S. forces on space assets, this too can only be an element of a broader space strategy. The United States cannot sacrifice its ability to use space in the event of conflict and hope that its military will be remotely as effective as it is today.

> The fact remains that a force content to operate without space assets would also almost certainly be a far less capable one than one able to leverage them.

Finally, the United States can also seek to raise the international political costs to potential adversaries of striking at U.S. space assets. It can do so through trying to reinforce norms against attacks against space assets, particularly those that cause space debris, and by collocating or otherwise associating U.S. national security payloads with foreign space assets.[48] The United States has also taken steps in these directions, engaging within a variety of international venues on space codes of conduct and other "rules of the road" for outer space, for instance.[49]

Nonetheless, there are limits to this avenue of approach as well. Formal, treaty-based, space arms control has long been a non-starter, and not by coincidence. Rather, the key implicated nations have fundamentally different views about the appropriate purposes and form of any such arms control agreement, views that are substantially influenced when not wholly derived from the different strategic perspectives that the United States, Russia, China, and other key states bring to the table.

Mingling U.S. space assets with those of other nations also faces constraints. While seeking to share space missions with other friendly nations can be helpful in sharing risk and raising the political and reputational costs to a potential attacker, the United States is unlikely to rely too much on placing core military missions on orbital assets that it does not exclusively control. And even in cases where the United States and a foreign state agree to share satellites, in the event of war with Russia or China such adversaries may not view a joint venture with a plausible space partner like the United Kingdom, Australia, or Japan – close U.S. allies that they are – as sufficient dissuasion to attack.

IV. Defense and Deterrence for Space: The Need for a Limited War Strategy for Space

Each of the abovementioned avenues of approach offers promise in helping the United States to deal with the growing perils to its space architecture. The United States should therefore explore all of these routes to mitigating the fundamental problems it faces in space, though the degree of investment and effort allocated to each will depend greatly on calculations of cost, capability, and risk that are (usually appropriately) hidden behind walls of secrecy. But while each course of action offers a partial means of addressing the growing threat to U.S. space assets, neither singly nor jointly can they fully meet the challenge. For even if the United States resolutely pursues all these avenues to mitigation, it is unlikely to change the fundamental reality that, in almost any plausible scenario, the United States will need to continue relying substantially on space assets that are vulnerable, and in many cases perhaps very vulnerable, to a wide variety of kinetic and non-kinetic threats.[50]

> The era of unchallenged U.S. dominance of space is over.

For the determinant reality is that the era of unchallenged U.S. dominance of space is over. Thus it is probable that some potential U.S. adversaries will, whatever corrective actions the United States is likely to pursue, be able to strike at U.S. space assets, and strike with possibly significant consequences for U.S. military power. Of course the scale and intensity of this threat will vary considerably based on the potential opponent – China and Russia will be more menacing in this respect than North Korea or Iran. But the fact remains that the United States is likely to face – and indeed is already facing – adversaries that can do serious damage to what is a vital component of U.S. military posture.

Thus, because some degree of vulnerability in space appears to be inevitable and because the United States is near certain to need to continue relying on space, the United States must find ways to protect its equities in space at least in part by *persuading* its adversaries not to exploit those vulnerabilities. More precisely, the United States needs to find ways to induce, convince, coerce, deter, dissuade, coax, incentivize, or otherwise persuade potential adversaries that can threaten U.S. space assets not to act on that ability or to limit the extent to which they do.

Unfortunately, there seems to have been little effort to develop a serious defense and deterrent posture for space until recently, and it is not clear that even commendable recent efforts to strengthen the U.S. space posture are guided by a clear strategic logic, despite the worsening problem.[51] Indeed, Congress was sufficiently concerned by the absence of such a coherent approach and the apparent lack of movement within the executive branch towards developing one that it felt compelled to mandate in the National Defense Authorization Act for Fiscal Year 2016 that the U.S. government develop such a strategy.[52] This arrested development has stemmed in part from the sense held until recently that U.S. space assets were largely safe, in part from concern in some quarters that developing a deterrent posture for space would contribute to or spur arms racing and the further militarization of the space domain, and in part from the vestigial sense that adversaries would be deterred from space attacks by the prospect of uncontrolled escalation. This last factor derived in part from the sense during the Cold War that the deterrent to attacks against space assets lay largely in the threat that such a step would likely be construed as a prelude to a general attack, and therefore greatly risk general nuclear war. Thus this legacy U.S. approach to deterrence of attacks against space assets relied, explicitly or latently, on the threat of a potentially overwhelming retaliation against even limited space attacks.

But such a threat is of substantially decreasing credibility. In today's much different context, no one really believes that a limited space attack would necessarily or even plausibly be a prelude to total nuclear war. Would the United States respond

with a major strategic strike if China or Russia, in the context of a regional conflict with the United States, struck discriminately at implicated U.S. space assets in the attempt to defang U.S. power projection, all while leaving the broader U.S. space architecture alone? Not only does such a massive response seem unlikely – it would be positively foolish and irresponsible. Furthermore, would other nations regard attacks on assets the United States was actively employing for a local war as off limits to attack? Indeed, any reasonable observer would have to judge that such discriminate attacks on U.S. space assets would not necessarily be illegitimate, as, by the United States' own admission, it relies greatly on its space architecture for conventional power projection.

Moreover, official U.S. statements on how the United States would respond to attacks on its space assets – to the limited extent such statements exist and the degree to which those given are clear – offer no indication it would respond massively to such strikes.[53] Perhaps more to the point, senior responsible U.S. officials have telegraphed that the United States would indeed not necessarily respond massively to attacks against its space assets.[54] In light of these factors, any U.S. space deterrence strategy that is predicated on an all-or-nothing retaliation to space attacks will become increasingly incredible and thus decreasingly effective – and indeed might even invite an adversary's challenge in order to puncture or degrade U.S. credibility.

> Any U.S. space deterrence strategy that is predicated on an all-or-nothing retaliation to space attacks will become increasingly incredible and thus decreasingly effective.

In other words, since space assets can increasingly be attacked segmentally and discriminately rather than totally, this means that credibly and effectively deterring such attacks requires a less than total response. Since the threat is more like a rapier than a broadsword, the United States needs rapier-like ripostes of its own. Accordingly, the United States needs a more discriminate deterrent for space. In particular, it needs a flexible deterrent capable of meeting the intensifying challenge of deterring an adversary – and particularly a highly capable potential opponent like China or Russia – from attacking (or attacking to a sufficient degree) those U.S. space assets needed for the United States to effectively and decisively project power and ultimately prevail in a conflict in a distant theater. At the same time, this flexible deterrent must contribute to dissuading such an enemy from striking at the nation's broader military and civilian space architecture, and in particular those core strategic space assets needed for central deterrence.

Put simply, the United States will need to find ways to limit war in space. Thus an effective U.S. strategy for space will need to be in substantial part an effective limited war strategy, meaning that the United States is going to want to find ways to *favorably* limit a war with such space-threatening adversaries. In essence, favorably limiting a war means that the terms of mutual limitation with the adversary allow the United States to prosecute the conflict successfully, at least with respect to the necessarily constrained political objectives that such a bounded conflict allows.[55]

But of course these terms of limitation will neither be set clearly in advance nor in stone. Accordingly, Washington's goals for shaping a conflict involving space should be twofold. First, the United States will want a limited war to be one in which it can use its space assets sufficiently to achieve victory, even if a limited one. At the same time, Washington will want to encourage potential adversaries such as Russia, China, and perhaps others to elect not to exercise their escalatory options, including their nuclear forces, against the United States and its allies. In short, the United States is not simply going to want to bound a war; rather, it is also going to want to shape any such conflict in ways that are sustainable during the conflict and which favor American objectives.

How might the United States go about developing the appropriate strategy and posture to accomplish this? Doing so involves two interrelated steps: developing formulae for bounding a conflict that allow the United States to operate effectively and

developing the capabilities and deterrent threats to enforce them, with the idea of winning the adversary and third parties' assent to these preferred boundaries. In other words, it means proposing the rules of the fight and then building the assets and strategy to incentivize an adversary's observance of them.

It is important to emphasize that, while distinct, these processes are mutually interactive. Proposed rules for limitation must of course allow for the United States to operate sufficiently effectively, but they also must be accepted by an adversary if they are to exercise a meaningful influence – and such acceptance can only come from some combination of the opponent's operational and political interests in bounding combat in space and his fear of the deterrent and defensive capabilities of the United States. By the same token, U.S. investments in space warfare capabilities must not only enable the defense of U.S. space assets and the ability to hold at risk those of the adversary, but, given that such investments cannot hope to deliver a full or even sufficient defense of the U.S. space architecture, need to be aligned with a limited war strategy and thus correlated to enforcing rules of limitation. Allowing such investments to proceed as if invulnerability were a realistic goal could result in wastage, frustration, or, at worst, undue escalation and even outright failure in the event of conflict.

The key, then, is to develop plausible norms of limitation that permit effective U.S. military operations but also seem sufficiently objective and reasonable to enlist at least some significant degree of adversary and third party buy-in, while simultaneously focusing on developing space deterrent and defense capabilities and associated operational concepts to enforce these norms in the context of building and operating a broader space architecture that can function sufficiently well within the proposed constraints. Ideally these processes should unfold in an interactive fashion, with assessments of the space military balance informing analyses of what U.S. proposed rules of limitation should be, and vice versa.

V. A Framework for Favorably Limiting War in Space

Setting Formulae of Limitation – "Rules" of War – in Space

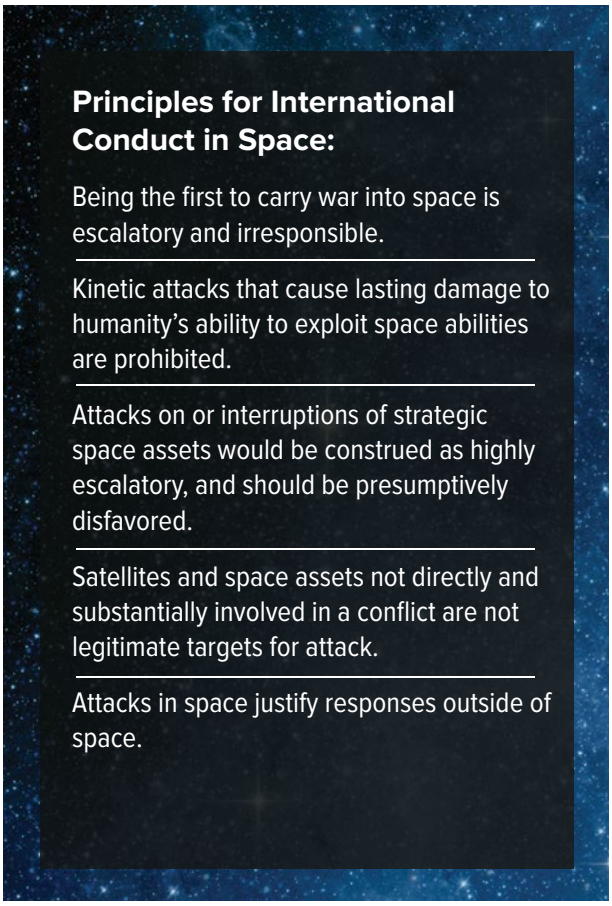
One half of this process is developing parameters for the limitation of war in space, as plausibly and favorably limiting a war means formulating and establishing desirable principles for restraint. Such principles form the substance of limitation, the formal or informal "laws" within which a restrained war would be conducted. To be effective in materially limiting a conflict, these principles must be sufficiently reasonable and mutually appealing to gain agreement among the warring parties as well as among the outside observers whose judgment will matter in encouraging (and perhaps enforcing, even if indirectly) the limitation of war. At the same time, to be attractive to Washington, such principles should enable the United States to employ force, including in space, in ways that can allow it to attain its basic political objectives. The principles should therefore be reasonable enough to seem fair, but favorable enough to allow Washington to use its military forces in advantageous and ultimately efficacious ways.[56] In the context of space, such principles should allow the United States to leverage its existing space assets or to develop new ones in ways that allow them to be sufficiently exploited to achieve (limited) U.S. military and ultimately political aims in the conflict.

This is, naturally, an inherently difficult and uncertain exercise. It is, of course, difficult to formulate principles that can both enable one's own success and attain the consent of one's adversary. This is not only due to the fundamental paradox involved in seeking to come to meaningful agreement on constraints with an enemy one is seeking to overwhelm, but also to the more practical difficulties of ascertaining a potential adversary's interests and perceptions. Furthermore, interests, perceptions, and technologies can and do change in ways that can undermine the legitimacy, appeal, or relevance of such proposed formulae for limitation. This problem is especially pronounced in the space and counterspace domain, given the secrecy that shrouds the programs of the United States, Russia, and China and the relative ignorance of space matters among large swathes of the policymaking echelons in all three countries.

Yet we know that such limitation of conflict can work, and can work in ways that enable a country prepared to fight a limited war to achieve its aims. In principle, of course, warring parties can find areas of agreement even while they compete and fight.[57] But history too shows that bargaining and negotiating while fighting is possible. Indeed, almost all wars are limited in some way, and all conflicts involving the nuclear-armed states since 1945 have been constrained in some meaningful way or another. For instance, while hardly a stellar example of how to effectively formulate and conduct a limited war, the experience in Korea demonstrates that the United States can agree to terms of limitation with an adversary and still achieve its basic objectives.[58] The experience of U.S. ally Israel in the Yom Kippur War, meanwhile, also shows a nation's ability to prevail (again, in limited terms) even under frameworks of limitation which it did not set or even find particularly favorable.[59] It is thus reasonable to expect that the United States could limit a war involving space attacks.

The rub, however, is in ensuring that the proposed rules of a limited warfare redound adequately to one's favor – as they did for Israel in the 1973 War (ultimately) – rather than against one – as they did against the United States in Vietnam.[60] What, then, should such proposed U.S. principles of limitation look like for space in the emerging strategic environment? Given the barriers to understanding the interests and equities of the United States in space formed by walls of classification, one can only provide tentative suggestions for such principles. Actual principles to be advanced by the U.S. government must be formulated in light of a full understanding of actual U.S. and potential adversary capabilities, as the appropriate U.S. demands will depend on assessments of the actual defensibility, clandestinity, resilience, and other aspects of the potential combatants' space assets, assessments unavailable to outside analysts. For instance, the less vulnerable the U.S. space architecture (or components within it), the less they will require defense from principles of limitation and the retaliatory threats encouraging their observance – and vice versa.

With that caveat, formulae for limitation the United States could consider might include the following:[61]



Being the first to carry war into space is escalatory and irresponsible.

While it seems imprudent for the United States to expect that, in a major conflict, space would be agreed to be a sanctuary, the United States still has an interest in raising the political and reputational costs of bringing a war into the space domain. For this reason, the United States has an interest in promoting the view that being the first to carry a war into space is particularly dangerous and irresponsible, and should be viewed as presumptively illegitimate. Such a norm would force a first mover into space warfare to incur "soft" political and reputational but still potentially significant costs, but would also avoid the United States having to take a full no first use pledge regarding strikes in space, which might unduly constrain the United States over the long-term if the space military balance develops unfavorably.[62]

Kinetic attacks that cause lasting damage to humanity's ability to exploit space abilities are prohibited.

Given the enduring dangers to all kinds of space-faring posed by space debris, this norm – already powerful – should be encouraged further from a defense point of view. Such a norm would be advantageous to the United States in the event of conflict because, while it would not bar non-kinetic attacks, which can be highly effective, it would nonetheless reduce the strike options available to an opponent by delegitimizing kinetic space attacks. This would help the United States both by narrowing the defensive problem to non-kinetic attacks, allowing the United States to concentrate on addressing such threats, and also complicate an adversary's challenges, for instance by undermining his confidence in the effectiveness of his attacks, since the results of non-kinetic strikes are harder to confirm.

Attacks on or interruptions of strategic space assets would be construed as highly escalatory, and should be presumptively disfavored.

A special presumption against attacks on strategic and nuclear-related systems could be established or, to the extent it is already implicitly understood, strengthened and formalized among the P-5 nuclear weapons states. In any limited war, the United States would want to avoid nuclear escalation due to "use them or lose them" concerns, inadvertent escalation stemming from the fog of a conventional war, or related pressures. Both the United States and an adversary like Russia or China would in fact share an interest in ensuring the confidence of the other in its ability to understand what was happening at the strategic nuclear level and in its ability to control its own nuclear forces.[63] This should lead to a common interest in establishing a norm that strikes on strategic space assets – for instance those involved in the control of and communication with strategic nuclear forces and in warning of long-range missile attacks – should be heavily disfavored.[64] Indeed, the United States could even go beyond the establishment of a principle along these lines by advocating the explicit identification of assets that would fall into this category, effectively "painting red" some

elements of the U.S. and potential adversaries' space architectures. Assuming such satellites are already at least to some meaningful extent vulnerable, such explicit identification would add to the deterrent defense of these assets by removing an adversary's ability to attack them while feigning ignorance of the actual function of such satellites.

As a corollary to this principle, however, the United States should work to disaggregate as much as possible its strategic space architecture from other functions, especially those involved in conventional warfighting. While this might entail additional expense and diminish the risk an adversary would face in attacking non-strategic space assets, the gains the United States would attain in stability, the recognized security of its strategic assets, and the greater legitimacy of U.S. strikes against adversaries' commingled systems by segregating strategic functions from others would appear to outweigh such costs.[65]

Such disaggregation would particularly strengthen the U.S. position that the mixture of conventional warfighting with nuclear and strategic-related systems should render such mixed assets legitimate targets in a limited war. If the United States were able to separate its strategic from non-strategic space assets, this would allow it to strike at (or threaten to strike at) adversary commingled assets or targets (in space or on Earth) with less fear that such an initiative might be turned against itself in domains where it commingles such assets. Since the United States would, in this case, not commingle its strategic with its non-strategic assets, it could extend a war into this domain advantageously (albeit still with the risk of escalation). In other words, such disaggregation would likely be advantageous even if done unilaterally because of the greater legitimacy it would provide. This has particular relevance for the United States in the context of a limited conflict with Russia or China, for instance with respect to Chinese missile forces.[66]

The elucidation and implementation of this principle regarding strategic space systems could productively be a special focus of space arms control. While they would pose considerable verification and categorization challenges, such efforts should in theory be potentially productive, as they would build on well-established arms control and strategic stability themes.[67] Efforts could include the identification of protected categories of space assets, potential means of identification and zones of operation for such assets, and, vitally, methods of verification to prevent cheating.

Satellites and space assets not directly and substantially involved in a conflict are not legitimate targets for attack.

Such a principle would establish a presumption that space assets not directly and substantially involved in a conflict would be treated as off-limits for attack, or at least that attacks upon them would be highly discouraged. This would be a valuable step for the United States, which is uniquely reliant on space and in particular on a range of space assets that may be somewhat involved in supporting military operations, but only to a limited degree. The United States would therefore benefit from a principle, such as this one, that would discourage attacks on large and valuable protected classes of space assets. The United States could also exploit the principle to protect a greater fraction of its architecture by responsively maneuvering and employing its existing space assets and developing new ones to take advantage of this principle, reducing the damage and risk Washington would incur in a conflict with an adversary able to strike at its space architecture.

At the same time, the principle would stand a good chance of being positively received, since it would leverage the intuitive and likely broadly shared sense among third party countries that space systems not directly engaged in the conflict should not be struck.[68] Such an intuition would build on the increasing interest among the growing number of spacefaring nations – including potential U.S. opponents – to limit the damage caused by war in space. And while U.S. adversaries might bridle at the proposed principle and the consequent political costs they would have to incur to attack protected U.S. space assets, they would be more able to accept such a restraint given the legitimation of strikes on space assets directly and substantially involved in the conflict.

Despite its appeal, this principle would face several significant challenges. First, even if it is accepted, it is difficult – even for the United States and thus even more for its potential adversaries – to accurately ascertain what each satellite is actually doing, and thus to determine reliably whether individual space assets are or are not significantly implicated in a conflict. Even beyond this problem of verifiability, this principle would also raise questions about what constitutes a space asset being "directly and substantially implicated." Indeed, the United States itself relies to a great degree on a host of satellites that perform both military and civilian functions – indeed, by some counts, most U.S. satellites do.

These pose serious problems to the meaningful effectuation of this principle and are especially pronounced given the value of clandestinity and deniability in space. Nonetheless, the United States, in concert with international partners, could seek to address this problem by establishing guidelines of how satellites not "directly and substantially" involved should behave and could be identified. These would require technical solutions beyond the scope of this report. That said, for instance, limits could be set on individual satellites' contact with military forces, measured by secure and encrypted means. Independent methods of verification, for instance through neutral parties, could be explored to ensure compliance.

It is also worth noting that this issue of the degree of involvement and methods of verification are a hoary set of problems in the context of limited war and indeed of wars in general, yet this criterion of limitation has generally been acknowledged and accepted, except in rare cases such as World War II. For instance, civilian or neutral shipping has almost always been acknowledged as a legitimate category for protection – yet has always also faced very serious and often unresolvable issues about ascertaining just what such shipping is doing. One particularly promising avenue could be to seek to enforce this principle *post hoc*, by publicizing cases in which an adversary has struck an innocent space asset. Such an approach would seek to influence an adversary's decisionmaking by threatening him with severe reputational (and ultimately other) costs if he selects a false positive – that is a space asset that he thinks or claims is "directly and substantially" involved in the conflict but is actually not.

Attacks in space justify responses outside of space.

The United States should seek to establish and deepen the principle that attacks in space can legitimately be responded to in other domains. That is, the United States should seek to fortify the sense that asymmetrical retaliation is legitimate in the face of attacks in space.

This is crucial to the United States' particular interests, given the greater current U.S. reliance on space and the consequent preference of its potential adversaries to confine legitimate retaliation in the face of such strikes to space itself. Yet such a candidate principle stands a strong chance of being more widely accepted as a wide gamut of countries have come to rely on space and appreciate its value and connectivity to the fullest range of civil and military applications. This should strengthen the case for the legitimacy of asymmetrical deterrence in response to attacks in space.

While these principles and approaches are offered primarily as illustrative examples – more stimulants for discussion than dictates to be etched in stone – they reflect the genre of rules the United States would want to promote.[69] These are informal laws that are sufficiently general and impartial to enlist the support and approbation of third parties and even potential adversaries, but that also would allow the United States to use space – even a more contested space – to execute its military operations effectively and ultimately to prevail in a limited conflict. The more firmly these principles became established, the more the United States could adapt its space architecture to them, focusing resiliency, defensive, and redundancy efforts more efficiently to exploit the opportunities afforded by a relatively stable set of expectations. Accordingly, the United States should seek to gain international diplomatic acceptance of these principles to the extent possible through codes of conducts and the like, since such formal ratification would raise the costs to adversaries of violating them.

The United States should not confine its deterrent and defensive efforts to the enforcement of these general norms, however. Rather, the United States should supplement its efforts to encourage observance of these advantageous general rules by seeking to promote more context-specific formulae of limitation. In particular, the United States should seek to develop a strategy and posture to protect even its space assets directly implicated in a conflict using deterrent threats and appropriate defenses. The United States should do so by making clear to potential opponents on more directly self-interested grounds that it would regard molestation of or attacks against certain satellites or types of satellites that would not be adequately shielded by general rules of space war limitation as also crossing important escalatory thresholds. That is, if an adversary can be persuaded that such attacks would be some combination of too costly in terms of the retaliatory response and too difficult in terms of the achievement of the desired result, then the United States could well be able to protect even important satellites that would not be covered by generally accepted norms (or insufficiently protected by such norms). Since the political costs of attacking such satellites would presumably be lower than attacking those covered by more broadly accepted principles, however, the United States would need to make these deterrent costs an adversary would incur correlatively greater.

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As a result, the United States should actually focus its defensive and deterrent efforts precisely on these systems that it would rely upon in a conflict, at least to the degree it has confidence that its adversaries are likely to abide by norms against attacks on systems not directly engaged in the conflict. Space defense capability should be allocated, in other words, not solely or even primarily based on the particular physical vulnerability of the space asset. Rather, because the United States will be seeking to deter attacks against certain types and classes of satellites through an adversary's observance of "rules" of limited warfare enforced by tailored retaliatory threats, the important systems that would actually be in net terms most vulnerable would be those *not* protected by such norms – particularly those directly implicated in a war. Accordingly, while the United States should invest in some degree of defenses for systems that are of particular value that would be protected by such norms, in part to shore up deterrent threats to avoid striking at them, the United States should concentrate its space defense and resilience

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The Apollo 4 Saturn V spacecraft prior to its inaugural launch on November 9, 1967. The Saturn V would eventually send the first astronauts to the Moon.

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A painting of a U.S. Air Force Defense Support Program satellite used to provide early warning of missile attacks.

investments in satellites that would actually be involved in a conflict, and thus would not enjoy protection by the norms of a limited war. Defenses and resilience would, in effect, compensate for the fact that such assets would be considered fair game in a conflict.

In sum, then, the United States should seek to develop a deterrent doctrine for its space assets that relies *both* on generalizable norms on the use of force in space *and* on focused threats to deter attacks on particularly important satellites or other space-related assets that would not be covered by broader norms. What would emerge is a layered or differentiated deterrent posture for space, one with different deterrent threats covering different space systems depending on their involvement in a conflict, their role in strategic missions, and other such factors.[70]

Enforcing the Formulae with Credible Threats and Tailored Capabilties

What would these crucial deterrent threats look like? As previously noted, adversaries could not be expected to observe general and particularly conflict-specific norms of limitation only through goodwill and the moral pressure of third parties. Rather, U.S. opponents would need to judge that observing such rules and demands would be the more prudent course not only due to the adversary's perception of the diplomatic and broadly reputational costs that would ensue from flouting such rules, costs that might seem worth bearing in the midst of a war with the United States, but also of their specific military consequences. Accordingly, there would need to be the credible threat of relevant military force hovering behind such laws and demands if there is to be any reasonable hope that an adversary is to abide by them.

These military consequences could be of two varieties: both the frustration of failure and the fear of retaliation. Using the classic formulation, for deterrence to work a potential adversary should judge that attacks on important U.S. space assets would either trigger costs more dear than any gains, view such efforts as too likely to fail and thus be counterproductive, or both.[71] Usually the United States tries to position itself so that it is able to deter by being able to deny an adversary any gains, since deterrence through the threat of inflicting costs requires the cooperation of the adversary to avoid or terminate escalation and may spark escalation itself through the nature of the retaliation. Hence, for instance, the United States seeks to deny the ability of North Korea and Iran to strike at the U.S. homeland with long-range missiles rather than rely only on its ability to retaliate.[72] This focus on deterrence by denial appears to be the aspiration of U.S. space policy.[73] But when vulnerability is a practically unalterable fact, as in the case of the U.S. space architecture, an exclusive concentration on deterrence by denial is ultimately a recipe for failure and possibly undue escalation. Accordingly, in such circumstances, the threat to impose costs sufficient to negate the appeal of the attack must become a vital part of an effective deterrent. Thus in the case of space the optimal deterrent approach for the United States will be a mixture of deterrence by cost imposition and deterrence by denial.

For deterrence to work, a potential adversary should judge that attacks on important U.S. space assets would either trigger costs more dear than any gains, view such efforts as too likely to fail and thus be counterproductive, or both.

It is important to emphasize that not only are these two forms of deterrence not necessarily exclusive, but that in this case they actually can and should be made to complement each other in a coherent limited war strategy. Deterrence by denial efforts should make it more difficult for an adversary to strike at and damage U.S. space assets, not merely for simple reasons of defense, but also to raise the costs and risks of doing so to an adversary and to make such an action more escalatory. If a U.S. opponent has to use a more destructive or larger weapon or set of weapons, strike at a broader array of targets, or cause more direct and peripheral damage in his attack, then the action is likely to spur and legitimate a more severe response on the part of the United States and cause more deleterious third-order effects. This prospect is more likely to deter the attack in the first place.

But it will only do so if the United States has retaliatory responses to such strikes that are frightening or formidable enough to induce restraint but also tailored and modest enough in their consequences that an opponent will believe they will actually be employed. An adversary, in other words, must not only see the stipulated retaliation as fearful and damaging but also as believably implementable. Furthermore, the nature of the retaliation threatened should be appropriately correlated to the importance and gravity of the attack that the United States is trying to deter. As Forrest Morgan aptly put it, "[I]t is less a question of whether would-be aggressors can be deterred from attacking U.S. space systems than of what kind of attacks against which capabilities could be deterred under what circumstances."[74]

By the same token, U.S. space defenses should be effective and cost-efficient enough to make a material difference in adversaries' potential calculations of how worthwhile attacking U.S. satellites would be. An enemy should see that U.S. space defenses are sufficiently good to significantly raise the costs, risks, and difficulty of striking at U.S. space assets. Such an assessment on the part of the adversary should contribute to deterring his attacking such assets in the first place by weighing on his fears that the attack will fail and the consequent wastage of important weapons or capabilities, that he will tip off the United States as to intentions or hidden assets, of the potential for escalation or embarrassment, that the attack will produce space debris or otherwise cause collateral damage, and other such factors. These disincentives should weigh meaningfully towards his forgoing such attacks in the

first place, or at least to narrowing or restraining them. It is important to observe that this is a different standard than the full protection of a satellite. The point is to meaningfully raise the costs and risks to the adversary of attacking, not to provide a full protection that is usually likely impossible and very likely to be an inefficient investment.

One can see here the interaction between the defensibility and hardiness of U.S. satellites and the ease or difficulty of formulating retaliatory threats needed to deter attacks upon them. While a full space defense may be unobtainable in the foreseeable future, the better defended, hardier, and more resilient the U.S. space architecture is, the more drastic will be the steps an adversary needs to take to materially damage it. And the more drastic those steps are, the more escalatory they will seem to be and thus the more credible and legitimate will more serious U.S. responses to such attacks appear. And thus the more deterred an adversary will be from embarking on such attacks in the first place. But, by extension, if an adversary can seriously undermine the U.S. space architecture with relatively discriminate force and with little collateral damage, U.S. retaliatory ripostes that might themselves seem highly escalatory will be less credibile and appealing in the event, leaving the U.S. space force significantly vulnerable to degradation in conflict.

The key for an effective U.S. limited war strategy for space, then, is to seek to raise the costs, the difficulties, the consequences, the violence, and ultimately the degree of escalation entailed by striking at the U.S. space constellation and its supporting infrastructure – while simultaneously developing tailored retaliatory options that, correlated to such escalation, would cause sufficient pain or damage to an adversary that he would find it more palatable to exercise restraint rather than his power.

What might such retaliatory options look like? It seems clear that some counterspace capabilities would be appropriate, especially non-kinetic ones, as such capabilities would help limit the conflict by responding to an adversary's space strike with a matching counterattack by the United States. Such capabilities will also be increasingly menacing to plausible opponents given their growing

The key for an effective U.S. limited war strategy for space, then, is to seek to raise the costs, the difficulties, the consequences, the violence, and ultimately the degree of escalation entailed by striking at the U.S. space constellation and its supporting infrastructure.

investments and presence in space. For instance, the United States could respond to attacks on its space architecture by China or Russia by striking at or employing disablement techniques against the opponent's space assets. Such counterstrikes might focus in particular on those assets vital for the opponent's ability to target crucial U.S. assets, such as aircraft carriers or other particularly lucrative but increasingly vulnerable targets. In the event of conflict with China, for instance, the United States could respond to attacks on U.S. satellites with strikes against the PRC's own satellite architecture that might be used in locating and targeting U.S. surface ships with China's DF-21D anti-ship ballistic missile or other strike assets.[75] Having this ability would require that the United States develop or maintain counterspace assets, primarily non-kinetic ones, that could be employed in accordance with preferred U.S. formulae for limitation but are nonetheless highly effective and whose results can be measured with a sufficient degree of reliability.

The problem with a purely mirroring retaliatory policy for the United States, however, is that Washington currently relies far more on space than its adversaries do.[76] It therefore does not make sense for the United States to confine itself to responses solely in the space domain since U.S. opponents are for the foreseeable future likely to be willing to forfeit their own use of space in exchange for compromising the U.S. ability to exploit it. In blunter terms, U.S. adversaries are at least for some time likely to be prepared to agree to a "mutual assured destruction" posture for space, since they would be better positioned in such an eventuality. It is the United States that cannot realistically afford such a result.

NASA

The Eastern Seaboard of the United States at night, as seen from the International Space Station. Demonstrating America's ability to prevail in a limited war in space is the best way to prevent such a war from happening.

Fortunately, there is no inherent need for the United States to respond to attacks in one domain with responses in the same domain. Indeed, it is important to emphasize that U.S. space deterrent threats need not be symmetrical, either in terms of the type or scale of the response. In point of fact, U.S. deterrent threats have long relied precisely on being asymmetrical and even disproportionate, especially when the United States has found itself at a strategic or operational disadvantage.[77] Accordingly, the United States should be prepared to reply to attacks against its space architecture, especially "out of line" attacks that violate its preferred formulae of limitation, with counterpunches, and potentially severe and painful ones, in other domains. For instance, the United States might respond in a terrestrial domain or in cyberspace to attacks in space. While the precise response should be calibrated to the gravity and damage of the initial strike, the United States should be prepared to respond firmly and even harshly to such attacks in ways that make clear to the adversary that Washington will not treat space as a segregated domain or one in which attacks will be treated as less serious. Cyberspace may offer a particularly attractive domain for retaliatory attacks by the United States, as cyberattacks can both do considerable harm, including to the very kinds of anti-satellite capabilities that would have been involved in the provoking initial strikes, and allow attacks against an adversary's homeland but do so in ways that are potentially more subject to calibration and thus less escalatory.[78]

As part of this broad strategy, the United States should seek to declassify or at least lower the level of classification of important parts of its deterrent posture for space. One of the challenges facing

the United States in deterring attacks against its space architecture is the very high walls of secrecy surrounding its space architecture and associated systems. While this is necessary in many cases, it also appears to be at least in part the product of inertia and tradition. This increasingly comes at a cost, as effective deterrence most reliably stems from demonstrated capability. If, therefore, the United States can openly and clearly show its ability to respond effectively and discriminately to attacks on its space architecture, this will contribute to adversaries' reluctance to strike at it.

In sum, then, the United States needs to develop tailored and effective retaliatory and defensive capabilities to encourage an adversary both to observe broader norms of limitation that would contribute to the security of the broader U.S. space architecture and to fear attacking even those U.S. space assets directly involved in a conflict sufficiently to enable the U.S. space system to meaningfully contribute to the U.S. ability to prevail in a limited war.[79]

This effort should also include an active diplomatic approach, particularly focused on semi-formal and non-treaty-based arms control. Indeed, such activities can play an important part both in promoting stability in space and in advancing specific U.S. interests in this regard. For instance, U.S. diplomacy should seek to promote the entrenchment as widely-accepted norms or rules of preferred U.S. formulae for limitation, and should seek to advance methods of verification and enforcement suitable for such limitation. If the United States can gain broad diplomatic support for its preferred rules of the road, this can create additional pressure on potential adversaries to observe such norms.

If the United States can openly and clearly show its ability to respond effectively and discriminately to attacks on its space architecture, this will contribute to adversaries' reluctance to strike at it.

Moreover, given that both the United States and its major power potential adversaries share an interest in strategic stability, Washington should seek to directly enlist both Moscow and Beijing's endorsement of such norms. Such activities need not take the form of formal arms control agreements but could be confined to less formalized engagement. For instance, Washington should make a special point of encouraging Russia and China to join it in disaggregating strategic from non-strategic space systems in the interests of strategic stability. The United States might also explore the merits of exchanging with these two potential adversaries signifiers of strategic systems, particularly highly vulnerable ones, that should be treated as "off-limits."[80] Additionally, the United States could pursue agreements to ban or at least punish the creation of debris in space, an agreement which should be relatively verifiable and would likely advance U.S. interests in raising the diplomatic and reputational costs of kinetic space attacks.[81]

VI. The Policy Implications of Adopting a Limited War Strategy for Space

What does the adoption of such an approach mean in practice in terms of changes to existing U.S. procurement, deployments, strategy, and organizations? Given the secrecy surrounding U.S. space and potential counterspace capabilities, it is beyond the scope or ability of this report to make recommendations regarding specific capabilities. What can be said, however, includes the following propositions.

To further its interests in space security, the United States should:

- Build a future space architecture that is prepared for war – and particularly for limitable war.
- Develop effective but limited forms of space attack, particularly non-kinetic ones that do not result in space debris.
- Procure and emplace space defenses on satellites in a way that is designed to raise the costs, risks, and uncertainty the adversary would encounter by striking at the system in question.
- Place a higher premium on declassifying or lowering the classification of important parts of its space deterrent posture in order to make clear to potential adversaries the ability of the United States to respond effectively and discriminately to attacks on its space architecture.
- Strive to segregate its strategic space architecture from other functions, especially conventional warfighting functions.
- Develop deliberate and adaptive planning capabilities for conflict in and affecting space, highly capable command and control systems and processes, and the creation of specific plans for how to conduct a war involving space, especially with countries like Russia and China.
- Understand what the diplomatic "market will bear" and then seek to gain agreement to and ideally support for preferred U.S. principles of how a war in space could acceptably unfold.
- Seek to influence space-related technology development in ways favorable to this strategy through engagement with allies, cooperation with industry, export controls, and the like.
- Seek to change perceptions of what the interests of the United States and its allies and partners require – and what is legitimate – with respect to defenses and conflict in space.

As a basic principle, **the United States should build a space architecture designed to conform to this defense strategy.** Accordingly, all future national security space assets should be designed and built with a clear sense for how they fit into such a broader space strategy that actively envisions how the U.S. architecture could survive and operate in a war involving space, particularly a limited one. This means no future space assets should be built without the defensive and resiliency capabilities needed for them to integrate into such an architecture, even at the cost of some sacrifice in capability. Tradeoffs will accordingly be necessary to ensure that space assets are constructed to survive and operate effectively in such a strategic context. In brief, the future U.S. space architecture should be one prepared for war – and particularly for limited war.

The United States should work to preserve or gain the ability to respond to attacks against its own space architecture with calibrated, discriminate attacks of its own in the space domain. **The United States should accordingly develop effective but limitable forms of space attack, particularly non-kinetic ones that do not result in space debris.** These forms of space attack should be able to be employed in graduated and tailored fashion such that they can be best correlated to the nature of the provoking attack. Such attack capabilities should also be developed in concert with formulae of limitation and should be designed to encourage their observation and to enforce them in the event of their violation.

This puts a premium on space situational awareness, such that the United States knows how and with what effect it has been struck, which of an adversary's assets it is most appropriate and useful

to attack, how best to do so, and what the results of such an attack are.[82] This requirement also extends to identifying terrestrial sources of attack, including non-kinetic forms that can be difficult to attribute accurately, such as jamming. Particular efforts should be made to be able to identify and effectively strike at adversary space assets that would be employed in an actual conflict, particularly in operations against especially important U.S. forces, such as aircraft carriers and other mobile assets.

At the same time, the United States should be prepared to strike asymmetrically in response to attacks on its space architecture, including beyond the space domain. While the United States should develop attractive options for intra-space conflict, U.S. space defense strategy should not give the impression that the United States will necessarily or even likely respond to attacks on U.S. space assets only in the domain of space.

Space defenses should be procured and emplaced on satellites in a way that is designed to raise the costs, risks, and uncertainty the adversary would encounter by striking at the system in question. While each space system would ideally have some defensive capability, as a general principle, defense investments should be concentrated on those space assets that are unlikely to enjoy the protection of formulae of limitation backed by credible retaliatory capabilities. In practice, this means that space defenses should largely be concentrated on those elements of the space architecture that would be engaged in a limited war and thus would be likely be perceived as legitimate targets for attack.

Somewhat counterintuitively, this would mean that some systems not directly involved in a limited war should be left more vulnerable than they otherwise might be. The logic of opportunity cost makes such a sacrifice inevitable, however, given that attempting to make every satellite maximally defended could consume the entire space budget. Investing heavily in defensive capabilities for space systems likely to be viewed as out of bounds during a limited conflict would, in effect, be wasting those investments. Moreover, leaving such systems vulnerable would make retaliatory threats more credible, as it would be clear the United States would not be relying on defenses for such assets. Of course, ensuring the existence of the capabilities and strategies to implement such threats of painful retaliation would be vital in making such an investment calculus prudent.

The United States should place a higher premium on declassifying or lowering the classification of important parts of its space deterrent posture in order to make clear to potential adversaries the ability of the United States to respond effectively and discriminately to attacks on its space architecture. Such an effort should extend beyond simple declassification to allowing or generating publicity around actual tests (consistent with U.S.-promoted norms, of course) of U.S. space deterrent and defense capabilities.[83]

The United States should strive to segregate its strategic space architecture from other functions, especially conventional warfighting functions. This is worth incurring considerable costs both in the interests of promoting strategic stability and in fortifying the U.S. position that commingling strategic and non-strategic assets should not be accepted as reason to accept such assets as outside the bounds of a limited war.

At the organizational level, **these trends also put a premium on the development of deliberate and adaptive planning capabilities for conflict in and affecting space, highly capable command and control systems and processes, and the creation of specific plans for how to conduct a war involving space, especially with countries like Russia and China.** More broadly, it places great value on the inculcation within the space community – notably including *both* the DoD and the intelligence community – of an appreciation of the need to think about and plan for such conflict. Unfortunately, thus far it is not clear that this has been encouraged sufficiently, let alone achieved.[84]

At the same time, the United States must integrate diplomatic considerations into its development of an effective space defense posture. As the United States should be striving to develop and gain acceptance for its preferred formulae for the limitation of war in space, so **it must understand what**

the diplomatic "market will bear" and then seek to gain agreement to and ideally support for preferred U.S. principles of how a war in space could acceptably unfold.

To the extent possible, **the United States should seek to influence space-related technology development** in ways favorable to this strategy through engagements with allies, cooperation with industry, export controls, and the like.

More broadly, **the U.S. government should seek to change perceptions of what the interests of the United States and its allies and partners require – and what is legitimate – with respect to defenses and conflict in space.** At a fundamental level, the United States needs to make clear that, given the threats it faces in space and the importance of the space domain to its legitimate interests, it needs to take meaningful steps to develop and build the capabilities for an effective limited war strategy for space. But to accomplish this, a range of influential actors need to be persuaded that this is indeed the case.

Within the executive branch, the DoD and other implicated agencies should make clear the priority of developing this posture. Officials within the defense and intelligence establishments should receive appropriate signals from formal documents, senior-level speeches, and the like that this represents a fundamental and lasting decision by the United States. There has already been substantial progress in acknowledging and highlighting the growing threat to the U.S. space architecture, but this needs to be accompanied by an embrace of an actual defense and deterrence strategy for space, and that this shift in perspective is lasting.

Within the U.S. government space community, defense and strategic requirements need to be given higher priority than they traditionally have been accorded. This means not only that strategic and defense considerations need to be factored into requirements for satellite acquisitions, for instance, but also that defense strategists need to be as involved in space procurement and policy deliberations as much as technical experts, engineers, and intelligence officers have been. Defense concerns regarding space also need to be appropriately elevated bureaucratically, for instance by elevating the rank of military officers and civilian officials responsible for formulation and implementation of space defense strategy.[85]

Within the broader U.S. policy conversation, key influential figures such as interested members of Congress and key defense policy influencers need to be consistently exposed to the need for this new approach to space. Such efforts would be materially aided by intelligently targeted declassifications of the threat to the U.S. space architecture, U.S. capabilities, and analyses of the likely dynamics of conflict in space.

Key U.S. allies and partners, especially those that cooperate with the U.S. in national security space, also need to be persuaded of the crucial importance of the need to develop such a new defense posture for space.

VII. Conclusion

For many years, the United States has been able to exploit the enormous advantages of space without needing to concern itself too much with how to defend its space architecture. The intensifying threats posed by plausible adversaries to U.S. space assets, however, make this legacy approach untenable. It is therefore incumbent upon the DoD and the other responsible agencies of the U.S. government to figure out how to continue to take advantage of space while also deterring attacks against the U.S. architecture and, in the event deterrence fails, to defend it. Failing to do so risks leaving the vital U.S. space architecture highly vulnerable – and thus invites U.S. adversaries to clip the U.S. military's "Achilles' heel."

The limited war strategy outlined here is one that acknowledges the reality of abiding vulnerability and the scarcity of resources, but that proposes a way of overcoming these challenges by constructing a space defense and deterrence posture built around preferred formulae of limitation, enforced by intelligently targeted investments in a mixture of retaliatory capabilities and space defenses, and strengthened by invigorated efforts to improve the resilience and redundancy, lower the costs, and minimize the fragility of the U.S. space architecture.

Such a posture would admit not just the possibility but even the legitimacy of war in space. This will strike many as too much of a concession. Should we not hold to the notion that any attacks in space would too probably lead to unconstrained and catastrophic escalation?

Of course this approach retains some attraction. The problem is that it just beggars the imagination that it will be honored in an age when space is as important to U.S. military operations as it currently is, and in which crucial U.S. space assets can be discriminately and effectively attacked. If we do not prepare for a limited war in space, then, we risk – indeed we court – being challenged precisely on this point, with the result being either the materialization of exactly the threat we have in the past relied upon – uncontrolled escalation – or, far more likely, the destruction in detail of crucial components of our vital space architecture without a suitable and sensible way to respond. We cannot risk something as important as our space posture on such a strategy.

Rather, the United States should continue to make clear that it would regard any attacks in space as constituting a grave form of escalation. But it should back that assertion with an ability to fight and prevail in a limited war in space. Nothing would be so likely to prevent any such war from happening, or to limit its baleful consequences should it break out, as a clear ability to do just that.

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44. Sandra I. Erwin, "Ash Carter's Idea of Disruptive Innovation: Unplug the Military From GPS," *National Defense Magazine,* April 27, 2015, http://www.nationaldefensemagazine.org/blog/lists/posts/post.aspx?ID=1817.

45. See, for instance, Andrew F. Krepinevich Jr., "How to Deter China: The Case for Archipelagic Defense," *Foreign Affairs* (March/April 2015), "Perhaps the first island chain's greatest vulnerability is the U.S. battle network – the critical systems that handle everything from directing and tracking troops and supplies to guiding weapons. This network currently relies heavily on satellites and nonstealth unmanned aerial vehicles, both of which the PLA could target. The best way to reduce that risk would be to establish a communications network of fiber-optic cables buried beneath the ground and the seabed along the chain, allowing disparate forces to safely receive and transmit data from hardened command centers on land. Island-based air defense and sea-denial forces, as well as antiship minefields, could protect the cable lines running between the islands."

46. Stew Magnuson, "U.S. Forces Prepare for a 'Day Without Space'," *National Defense Magazine*, February 2014, http://www.nationaldefensemagazine.org/archive/2014/February/Pages/USForcesPreparefora%E2%80%98DayWithoutSpace%E2%80%99.aspx.

47. I am grateful to Forrest Morgan for these points regarding the limitations of non-space assets.

48. This is emphasized in Department of Defense and the Office of the Director of National Intelligence, *National Security Space Strategy*.

49. Arms control discussions on space have thus far been very limited and occur primarily in the Conference on Disarmament. The Conference on the Peaceful Uses of Outer Space, meanwhile, has been pursuing "best practice guidelines" for the long-term sustainability of outer space. This initiative is complementary to security initiatives. The Code of Conduct is an ad hoc multilateral initiative led by the European Union outside the United Nations framework. There has been more thinking on space arms control outside of formal channels, however. For a leading thinker's ideas for space arms control, albeit from a different perspective than this analysis, see Michael Krepon, Director of the Stimson Center's Space Security Program, testimony to Subcommittee on Strategic Forces, House Armed Services Committee, U.S. House of Representatives, January 28, 2014, http://www.stimson.org/images/uploads/research-pdfs/Krepon_Testimony_HASC_1-28-14.pdf.

50. For a similar view, see Roger G. Harrison, Collins G. Shackelford, and Deron R. Jackson, "Space Deterrence: The Delicate Balance of Risk," *Space and Defense* 3, no. 1 (Summer 2009), 1–30.

51. For an excellent exception to the general neglect of this problem, see Morgan, *Deterrence and First Strike Stability in Space*. Morgan's superb monograph expertly outlines a broadly similar approach to the one taken here, albeit with important differences on some specific points. For other honorable exceptions, see Jay Finch and Shawn Steene, "Finding Space in

Deterrence"; and Harrison, Shackelford, and Jackson, "Space Deterrence."

52. U.S. House of Representatives, *National Defense Authorization Act for Fiscal Year 2016*, H.R. 1735, 114th Cong., 1st sess., http://docs.house.gov/billsthisweek/20150928/CRPT-114hrpt270.pdf. See also Office of Senator John McCain, "SASC Chairman McCain on National Defense Authorization Act," May 14, 2015, http://www.mccain.senate.gov/public/index.cfm/press-releases?ID=6713b99e-30d3-4407-9443-3e3a2694590b.

53. For more on the largely ambiguous U.S. declaratory policy relating to responses to attacks against U.S. assets in space, see, for instance: "Space as a Vital National Interest" (The German Marshall Fund, August 2005), http://marshall.org/wp-content/uploads/2013/08/315.pdf; "Space and U.S. Security: A Net Assessment" (The Institute for Foreign Policy Analysis, Inc., January 2009), http://www.ifpa.org/pdf/Space_and_U_S_Security_Net_Assessment_Final_Dec15_08.pdf; Lee Billings, "War in Space May Be Closer Than Ever"; and President of the United States of America, *National Space Policy of the United States of America* (June 2010), https://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

54. See, for instance, the remarks of then-Assistant Secretary of Defense for Global Strategic Affairs Madelyn Creedon at The Stimson Center on September 17, 2013, particularly during the question and answer period, and, more recently, the keynote address of Admiral Cecil Haney, Commander of U.S. Strategic Command, "Deterrence Symposium Opening Remarks" (USSTRATCOM Deterrence Symposium, July 29, 2015), https://www.stratcom.mil/speeches/2015/136/Deterrence_Symposium_Opening_Remarks/. Deputy Secretary of Defense Robert Work also pointed out that the United States "must be able to respond in an integrated, coordinated fashion" against space attacks. Colin Clark, "DepSecDef Work Invokes 'Space Control;' Analysts Fear Space War Escalation," *Breaking Defense,* April 15, 2015, http://breakingdefense.com/2015/04/depsecdef-work-invokes-space-control-analysts-fear-space-war-escalation/.

55. For a broader discussion of this proposition, see the author's article in the November/December 2015 issue of *The National Interest* entitled "Preparing for Limited War," and, for a particular analysis of the problem in the China context, see Elbridge Colby, "China's Offensive Missile Forces: Implications for the United States," Testimony before the U.S.-China Economic and Security Review Commission, April 1, 2015. For useful and important studies of the problems of limited war, see, for instance, Robert E. Osgood, *Limited War: The Challenge to American Strategy* (Chicago: University of Chicago Press, 1957); Robert E. Osgood, "The Reappraisal of Limited War," *The Adelphi Papers* 9, no. 54 (1969); Alastair Buchan, "Problems of Modern Strategy: Part I," *The Adelphi Papers* 9, no. 54 (1969), 41–54; Henry Kissinger, *Nuclear Weapons and Foreign Policy* (New York: Harper & Row, 1957); Bernard Brodie, *Strategy in the Missile Age* (Princeton, N.J.: Princeton University Press, 1959); Herman Kahn, *On Thermonuclear War* (Princeton, NJ: Princeton University Press, 1960); Glenn Snyder, *Deterrence and Defense: Toward a Theory of National Security* (Princeton, NJ: Princeton University Press, 1961); Klaus Knorr, ed., *Limited Strategic War* (New York: Frederick Praeger, 1962); Morton Halperin, *Limited War in the Nuclear Age* (New York: John Wiley & Sons, 1963); Herman Kahn, *On Escalation: Metaphors and Scenarios* (New York: Frederick A. Praeger, 1965); Bernard Brodie, *Escalation and the Nuclear Option* (Princeton: Princeton University Press, 1965); Thomas Schelling, *Arms and Influence* (New Haven: Yale University Press, 1966); Richard Smoke, *War: Controlling Escalation* (Cambridge, MA.: Harvard University Press, 1977); Robert Osgood, *Limited War Revisited* (Boulder, CO: Westview Press, Inc., 1979); Forrest E. Morgan, Karl P. Mueller, Evan S. Medeiros, Kevin L. Pollpeter, and Roger Cliff, *Dangerous Thresholds: Managing Escalation in the 21st Century* (Santa Monica, CA: RAND Corporation, 2008); and Jeffrey Larsen and Kerry Kartchner, *On Limited Nuclear War* (Palo Alto, CA: Stanford University Press, 2014).

56. For an example of this approach in the context of strategic forces, see Elbridge Colby, "Reconciling Stability and Deterrence" in *Strategic Stability: Contending Interpretations,* eds. Elbridge Colby and Michael S. Gerson (Carlisle, PA: U.S. Army War College Press, 2013). For an application of this approach to the space domain, see Finch, "Bringing Space Crisis Stability Down to Earth."

57. Thomas C. Schelling, *Arms and Influence* (New Haven: Yale University Press, 1966).

58. For an analysis of this, see Henry Kissinger, "The Dilemma of Containment: The Korean War," in Henry Kissinger, *Diplomacy* (New York: Simon and Schuster Paperbacks, 1994), Chapter 19, 473–492; Osgood, *Limited War.*

59. For discussions of this dynamic in the Yom Kippur War, see, for instance, Elbridge Colby, Avner Cohen, William McCants, Bradley Morris, and William Rosenau, "The Israeli 'Nuclear Alert' of 1973: Deterrence and Signaling in Crisis" (Center for Naval Analyses, April 2013).

60. For instance, many analysts point to the restrictions placed on the U.S. ability to strike at North Vietnamese and Viet Cong redoubts and supply routes in Cambodia and Laos and ultimately at North Vietnam itself as a key reason for the U.S. failure in the war in Indochina. For a discussion of the negative implications of the terms of limitation against the United States in Vietnam, see William W. Momyer, *Air Power in Three Wars* (Washington, DC: Department of the Air Force, 1978), and Admiral U.S. Grant Sharp, *Strategy for Defeat: Vietnam in Retrospect* (San Rafael, CA: Presidio Press, 1978).

61. Some of these principles could build upon the Law of Armed Conflict, as interpreted by the United States in Department of Defense, *Law of War Manual* (June 2015), http://www.defense.gov/Portals/1/Documents/pubs/Law-of-War-Manual-June-2015.pdf.

62. For a powerful argument for such a restrictive formula, see Morgan, *Deterrence and First Strike Stability in Space*, 37–45. Morgan argues that the United States should openly condemn any state that strikes in space first, thereby strengthening the taboo against space warfare in order to raise deterrence costs for would-be attackers and laying a foundation of moral legitimacy for punishing violators. He argues the United States should explicitly condemn any use of force in space except in retribution for attacks on one's own space systems. Accordingly, he argues that the United States needs to bring as broad a range of deterrent capabilities to bear as possible, including the ability to defend U.S. space assets and impose retribution on attackers in space as well as the terrestrial military, political, and economic domains.

63. Nor should U.S. adversaries be the only ones concerned about such vulnerabilities. While it is very hard, given classification barriers, to obtain a reliable assessment of how vulnerable U.S. nuclear C4ISR systems are to adversary attack, recent reports indicate sanguinity is not justified. See for instance, Government Accountability Office, *Nuclear Command, Control, and Communications: Update on DOD's Modernization* (June 15, 2015), referring to "gaps or weaknesses" in the NC3 system. For an analysis of these potential vulnerabilities, particularly in the space realm, see Loren Thompson, "Watchdog Agency Warns Of 'Weaknesses' In Nuclear War Command Links," *Forbes*, June 22, 2015. See also the comments in 2014 of General William Shelton, "Take one of those out and you have opened up a big gap in our ability to communicate over protected resources." General William Shelton, USAF, who at the time headed Air Force Space Command, made these comments in reference to the AEHF satellites at a 2014 hearing of a Senate Armed Services panel. He called it the "cheap shot" scenario. General William Shelton, USAF, Commander, Commander of Air Force Space Command, "Military Space Programs," Senate Armed Services Subcommittee on Strategic Forces, U.S. Senate, March 12, 2014, 16. See also Shelton's comments at the Atlantic Council: "If an adversary were to take out one, just one, satellite in the constellation, a geographic hole is opened and we potentially have a situation where the president can't communicate with forces in that part of the world." "Transcript: The U.S. Future in Space." For an update on the status of the AEHF constellation, see Mike Gruss, "U.S. Air Force Declares Three-satellite AEHF Constellation Operational," *Space News*, August 10, 2015.

64. One potentially very significant problem in establishing and ensuring the observation of such a principle, however, is that U.S. satellites that provide strategic early warning would also be important for the hunting of and attacks on an adversary's mobile systems, including conventional systems that might be considered legitimate targets even in a limited, non-nuclear conflict. See Morgan, *Deterrence and First Strike Stability in Space*, 20.

65. This question presents a difficult tradeoff, with merit on both sides. Some argue that the greater caution that commingling induces in an adversary is worth the risk of more catastrophic escalation if such commingled space assets are attacked. Resolution of this issue of course depends on judgments about risk, benefit, and cost. But if the space-based strategic assets are genuinely of great strategic value, then leaving them not only vulnerable but – at least arguably – legitimately targetable seems more risky than it is worth. The potential loss of such strategic functions does not appear worth the gain in greater deterrence of attacks against space operations supporting conventional warfighting.

66. For an elucidation of this logic, see Elbridge Colby, "Don't Sweat AirSea Battle," *The National Interest*, July 31, 2013, http://nationalinterest.org/commentary/dont-sweat-airsea-battle-8804.

67. See Thomas C. Schelling and Morton Halperin, *Strategy and Arms Control* (New York: Twentieth Century Fund, 1961). For a powerful and persuasive recent statement of the case, see Finch, "Bringing Space Crisis Stability Down to Earth," 15–20.

68. See, for instance, Ali Wither, "We Might be Closer to an International Code of Conduct for Outer Space," Motherboard, August 17, 2015, http://motherboard.vice.com/read/we-might-be-close-to-an-international-code-of-conduct-for-outer-space.

69. For other, related potential themes, see, for instance, Bruce W. MacDonald, "China, Space Weapons, and U.S. Security," 10-11; Department of Defense, *Space Policy*, Directive (October 18, 2012); Department of State, *An International Code of Conduct for Outer Space Activities: Strengthening Long-Term Sustainability, Stability, Safety, and Security in Space: Fact Sheet* (January 17, 2012).

70. How this could be accomplished is a promising avenue for future research and analysis.

71. For a recent statement, see the Department of Defense, *Deterrence Operations Joint Operating Concept* (December 2006), 5–6. For the classic formulation, see Glenn Snyder, *Deterrence and Defense: Toward a Theory of National Security* (Princeton, NJ: Princeton University Press, 1961).

72. Department of Defense, *Ballistic Missile Defense Review Report* (February 2010).

73. See, for instance, the comments of General Hyten in the 60 Minutes interview: "Gen. John Hyten: Right. And deterrence in the space world has got to be built on a little bit different construct. It's the ability to convince an adversary that if they attack us, they will fail." Martin, "The Battle Above."

74. Morgan, *Deterrence and First Strike Stability in Space*, 17.

75. For the assessment that China is believed to be using satellites to target U.S. warships, see Donnelly, "Battlefield: Space."

76. Finch and Steene, "Finding Space in Deterrence," 11–13.

77. For the development of the concepts of symmetrical and asymmetrical strategies, see John Lewis Gaddis, *Strategies of Containment: A Critical Appraisal of American National Security Policy during the Cold War* (New York: Oxford University Press, 2005).

78. I am grateful to Jay Finch for this last point.

79. Developing more concrete and specific recommendations for how to implement this would be a very useful focus of further research and analysis.

80. Naturally, such an exchange would present numerous problems, including that both sides would have an interest in expanding such protections beyond what might genuinely be justified, of verification, and of deception. Nonetheless, in principle such engagement could promote stability.

81. For an argument for this proposal and a persuasive argument for the merits of deterrence and stability-oriented space arms control, see Morgan, *Deterrence and First Strike Stability in Space*, 40–41.

82. Space awareness and command and control received particular attention in the Department of the Air Force's "Memorandum for AFSPC Long-Term Science and Technology (S&T) Challenges," but the broader concept of the development of a flexible limited war capability for space did not.

83. A corollary to this would be the U.S. Navy's publicity of the long record of success of its vaunted Trident II D5 submarine-launched ballistic missile, the backbone of the nation's nuclear deterrent. The consistent success of this program and publicity surrounding this fact is thought to contribute to confidence – among both allies and potential adversaries – in the system's ability to perform its mission with devastating accuracy. Loren B. Thompson, "Navy's Trident II Missile Shows Why It's the Backbone of the U.S. Nuclear Deterrent" (Lexington Institute, July 22, 2014), http://lexingtoninstitute.org/navys-trident-ii-missile-shows-why-its-the-backbone-of-the-u-s-nuclear-deterrent/, and Richard Tomkins, "Navy flight tests Trident II ballistic missiles," UPI, February 25, 2015, http://www.upi.com/Business_News/Security-Industry/2015/02/25/Navy-flight-tests-Trident-II-ballistic-missiles/9301424876998/.

84. Colin Clark, "Would Spies Command In A Space War? Dunford Says Maybe," *Breaking Defense*, July 22, 2015.

85. For instance, U.S. operations in a space contingency would currently be led by a three-star general officer subordinate to U.S. Strategic Command. This strongly suggests that the Defense Department is not yet prepared to treat space as a legitimate domain for warfighting, and represents a markedly different approach than that for U.S. Cyber Command, for instance, which is headed by a four-star officer. Consideration should therefore be given to elevating the importance within the Defense Department of preparing for conflict in space, particularly at the Joint level.

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Center for a New American Security

1152 15th Street, NW
Suite 950
Washington, DC 20005

TEL 202.457.9400
FAX 202.457.9401
EMAIL info@cnas.org
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