2013-09

Anti-satellite Weapons, Deterrence and Sino-American Space Relations

Krepon, Michael

September 2013

Stimson Center

STIMSON

Anti-satellite Weapons, Deterrence and Sino-American Space Relations

Michael Krepon & Julia Thompson, Editors

SEPTEMBER 2013

Anti-satellite Weapons, Deterrence and Sino-American Space Relations

Michael Krepon
Julia Thompson
Editors

September 2013

TABLE OF CONTENTS

Preface

I am pleased to present Stimson's latest publication: Anti-satellite Weapons, Deterrence and Sino-American Space Relations. The Stimson Center, under the leadership of co-founder and Space Security Project Director Michael Krepon, has advanced the concept of a code of conduct for responsible spacefaring nations, and regularly hosts important conversations on space issues and challenges.

Over the past two years, Stimson programming has focused on deterring attacks on space assets, promoting greater cooperation in space between the United States and China and avoiding a dangerous military competition in space. This collection of essays, edited by Michael Krepon and Research Associate Julia Thompson, captures important insights from Stimson Center workshops, roundtables and public events. Stimson has assembled a Distinguished Advisory Group (DAG) to help us consider these issues, with members drawn from government, the private sector, academia and non-governmental organizations. Members of the DAG helping to guide the project's research agenda include: James Acton, Paul Bernstein, Richard Betts, Sam Black, Barry Blechman, Lincoln Bloomfield Jr., Linton Brooks, Elaine Bunn, Elbridge Colby, Daniel Deudney, Andrew Erickson, Jay Finch, David Hamon, Roger Harrison, Peter Hays, Theresa Hitchens, Robert Jervis, Dana Johnson, Kerry Kartchner, Frank Klotz, Ed Lacey, James Lewis, Jeffrey Lewis, Bruce MacDonald, Vincent Manzo, Patrick McKenna, Frank Miller, James Clay Moltz, Forrest Morgan, Karl Mueller, Michael Nacht, George Nacouzi, Michael O'Hanlon, Brad Roberts, Victoria Samson, Philip Saunders, John Sheldon, Paul Stares, Shawn Steene, Brian Weeden and Mike Wheeler.

It will not be easy to create consensus on how best to deter attacks against critical US assets in space. Applying principles of deterrence to the space domain is a new but essential field of inquiry. As evidenced by these essays, Stimson's workshops revealed varied perspectives on the prospects for cooperation, competition and deterrence in space. We hope that this publication will stimulate further analysis of these important subjects.

I wish to express gratitude to the Defense Threat Reduction Agency and the New-Land Foundation Inc. for their support for this project. This material is made possible in part by support from the Project on Advanced Systems and Concepts for Countering Weapons of Mass Destruction (PASCC), Center on Contemporary Conflict, Naval Postgraduate School, under Grant No. N00244-12-1-0027 PASCC is supported by Defense Threat Reduction Agency (DTRA). The project also wishes to thank Stimson's Communications team—David Egner and Rich Robinson—copy editor Nancy Lewis, designer Neal Ashby, and intern Sonya Schoenberger for their production support.

Sincerely,
Ellen Laipson
President and CEO, Stimson Center

Introduction

US national security experts spend years studying, seeking to avoid and sometimes helping to mediate or prosecute conflicts. Over time, veteran policy hands in the executive and legislative branches, as well as academia, thinks tanks and the media, come to believe that they understand all the important dimensions of security. And yet, for most, one dimension – space – presents a significant gap in their understanding. Space's importance is major, growing and underappreciated inside the Washington Beltway.

Over a half century ago, the US-Soviet space race captured the imagination of the American people, and the manned space program from the 1960s onward bred national competence in the design, manufacture and launch of rockets, satellites and payloads with ever-greater capabilities. Scientific study, helped by access to space, flourished. Civil and military use of space-based communications grew fast as the internet, personal computing and cellular telephony gained widespread adoption beginning in the 1990s. By the end of the decade, the Pentagon recognized that the US military had developed a dependence on spaced-based communications, such that a sudden denial of space-enabled information in wartime could impair the effectiveness of combat units.

The military saw from wargaming simulations of future conflict that space assets were like a crystal goblet: exquisite but easily shattered. An adversary would naturally contemplate measures to disable US forces' ability to command and control operations across an entire theater of operations, and to access real-time intelligence and targeting data supplied from distant sources. The enormous warfighting advantage afforded to US forces by space systems was, because of its vulnerability, perceived as an Achilles heel. The conclusion was logical: space had to be defended.

Space became a "domain," talked about by defense analysts as one of several discrete arenas of potential confrontation, like air, land, sea or nuclear – or more recently, cyber. For security experts, these can be useful categories; yet here is where the underappreciation of space becomes acute. It is not just that traditional "terrestrial" warfare, involving loss of life, destruction of property and territorial conquest imposes readily-visible costs that society has long recognized as vital interests, while the idea of attacking satellites in space seems a lesser level of aggression. The deeper problem is with the long-term consequences of destructive conflict in space, for these may be poorly anticipated by policymakers during a time of hostilities, and yet, in retrospect, these may prove to be more regrettable than all but the most destructive acts of war in the other "domains."

Presidents in the 21st century will expect to exercise close control over any major future crisis; many regard the 1962 Cuban Missile Crisis as the template for wise, clever, well-advised presidential decision-making in an escalating confrontation. And yet, as useful as experience from the nuclear playbook is, wargames have suggested important differences, one of which is that the space domain imposes a particularly forbidding time element on the management of a space crisis. Not only will time be lost in detecting that US space systems have been interfered with, but knowing with certainty that a space system anomaly was due to attack, and assigning unmistakable attribution, will consume precious time as well.

Because entire constellations of valuable satellite systems rotating the Earth could be destroyed quickly if indeed an adversary is targeting them, military commanders with expertise and responsibilities in the space domain will press for an immediate presidential grant of authority to take action. Are security generalists comfortable that they could advise the president on decisions and actions that would best serve the US interest in such a scenario?

What makes this domain, and the study of deterrence in space, at once different and underappreciated, is the aftermath. Conventional wars can produce fearsome destruction; lost lives cannot be replaced, but societies recover. Even the nuclear accidents at Chernobyl and Fukushima instruct us that relatively small nuclear exposure of civilian populations can be extremely hazardous and hard to manage; yet societies can pursue measures to cope with their effects, and recover.

Imagine, however, a future conflict in which space assets are targeted with destructive force. The US Air Force Space Command in recent years hosted wargaming exercises that simulated, in one instance, hostilities that required US and allied forces to operate for "a day without space." While loss of space-based communications was mitigated by terrestrial systems, the consequences for operating in space were certainly not remedied in a day. Indeed, participants were left to speculate if the United States might be contemplating a century or even much longer "without space."

Consider what this could mean for the reputation of the United States, and for the trajectory of human discovery. Unchecked, hostile action in space could produce debris, orbiting the earth at nine times the speed of a bullet, so prevalent as to put at risk all sophisticated spacecraft including satellites. This could place manned and unmanned space flight at unacceptable risk of mission failure due to catastrophic collision with debris. Not only would investment in, and insurance for, advanced spacecraft and launch engineering be extinguished. Of much greater importance, mankind's access to space for exploration and pursuit of knowledge would be closed off – for young and old alike, for schoolchildren, scientists and aspiring astronauts, in America and around the world, possibly for a very long time. A more toxic legacy for US security policy would be hard to conceive.

That is why the study of space deterrence should matter to all policymakers, and why the Stimson Center's Space Security project, led by Stimson co-founder Michael Krepon, is pleased to present this collection of six essays studying deterrence of destructive acts in space, drawing from lessons from the nuclear era. I hope you find them of interest.

Lincoln P. Bloomfield Jr.
Chairman, Stimson Center

Acronyms and Key Terms

A2/AD – anti-access/area denial
ASAT – anti-satellite
BMD – ballistic missile defense
GEO – geosynchronous orbit
GGE – Group of Government Experts
GPS – global positioning system
ICBM – intercontinental ballistic missile
ICOC – International Code of Conduct for Outer Space Activities
ISR – intelligence, surveillance and reconnaissance
ITAR – International Traffic in Arms Regulations
LEO – low Earth orbit
LTBT – limited test ban treaty
MEO – middle Earth orbit
MIRV – multiple independently targetable re-entry vehicles
NASA – National Aeronautics and Space Administration
NRO – National Reconnaissance Office
OST – Outer Space Treaty
PNE – peaceful nuclear explosions
PLNS – pre- and post-launch notification system
PNT – precision navigation and timing
PPWT – Prevention of the Placement of Weapons in Outer Space and the Threat or Use of Force Against Outer Space Objects
SALT – Strategic Arms Limitations Talks
SDI – Strategic Defense Initiative
SEIS – space-enabled information services
START – Strategic Arms Reduction Treaty
TCBMs – Transparency and Confidence Building Measures
UNCOPUOS – United Nations Committee on the Peaceful Uses of Outer Space
WMD – weapons of mass destruction

Space and Nuclear Deterrence

By Michael Krepon

"Space deterrence" is defined here as deterring harmful actions by whatever means against national assets in space and assets that support space operations. Analogously, nuclear deterrence is defined as deterring harmful actions by means of nuclear weapons. Concepts of nuclear deterrence have been well developed. In contrast, attention to space deterrence has been sporadic during and after the Cold War, sparked mostly when anti-satellite (ASAT) capabilities have been tested. These concerns faded after the demise of the Soviet Union, and have now revived with the advent of China's ambitious space program.

DEMONSTRABLE VS. INFERRED DETERRENCE

Nuclear deterrence and space deterrence have common elements as well as distinct differences. No difference is more striking than with respect to the visibility of nuclear deterrence capabilities compared to the largely inferential nature of space deterrence. The advent of nuclear weapons was advertised with spectacular effect, with the mushroom cloud immediately becoming the symbol of the "atomic age." Ever since, nuclear deterrence widely was presumed to be strengthened by visible displays. Tests of warhead designs were carried out in the atmosphere and were subsequently driven underground, easily confirmed by seismographs. Missile flight tests repeatedly affirmed vigilance and readiness. Some states possessing nuclear weapons still parade nuclear-capable missiles on national holidays.

> *capabilities to harm space assets have been pursued quietly or by indirect methods*

In contrast, capabilities to harm space assets have been tested only occasionally in dramatic ways and mostly have been pursued quietly or by indirect methods. Consequently, space warfare capabilities rarely make headlines, unlike actions signaling nuclear deterrence, which are the subject of intense public and media attention. While nuclear deterrence rests on deployed or readily deployed capabilities, the weaponization of space – defined here as the placement of dedicated war-fighting capabilities in this domain – has yet to occur. The nuclear superpowers deployed large numbers of nuclear weapon delivery vehicles carrying thousands of warheads, many ready for launch on short notice. At the same time, military capabilities specifically designed to harm satellites were rarely deployed, had limited operational utility, and were subsequently mothballed during the Cold War.

The Eisenhower administration considered contesting a Soviet "right" to have its Sputniks orbiting over US soil, but thought better of it: American satellites would soon follow – including ones revealing military secrets in a closed society. It took no great gift of prophecy to foresee benefits accruing from the norm of free passage. The Kennedy administration saw fit to position a crude ASAT capability in the Pacific after the Cuban Missile Crisis – a decision that extended into the Johnson and Nixon administrations. This capability was hardly worth the bother in military terms. Presidents John F. Kennedy and Lyndon Baines Johnson were far more interested in beginning to establish norms for the peaceful uses of outer space. The Soviet Union was soon eclipsed by the United States in the "space race," and was amenable to downplaying the prospect of confrontation in this domain. In 1967, the nuclear superpowers agreed to the Outer Space Treaty, their second major codified constraint of their strategic competition, after an agreement four years earlier to stop testing nuclear weapons in the atmosphere.

> *a striking aspect of these periods of heightened competition was how careful both superpowers were not to cross each other's red lines in space*

There were, to be sure, periods of heightened military friction and competition in space, particularly following Soviet ASAT tests in the 1970s and after President Ronald Reagan's announcement of the Strategic Defense Initiative in 1983. In retrospect, a striking aspect of these periods of heightened competition in space was how little residue they left on the strategic competition, and how careful both superpowers were not to cross each other's red lines in space, as well as on the ground and at sea. Just as Washington and Moscow learned not to play with fire in particularly sensitive zones after crises over Berlin and Cuba, so, too, did they reach tacit and formal agreements not to create havoc with each other's satellites – despite multiple capabilities that enabled them to do so.

One reason why demonstrable deterrence was deemed crucial for the nuclear competition, while inferential deterrence would suffice for space, was that military capabilities designed for one domain – including missiles deployed for the purpose of nuclear deterrence and for missile defense intercepts – could be used in the other. Another reason was that after crises in Berlin and Cuba, the United States and the Soviet Union acted for the most part as status quo powers. Will this Cold War record of uncommon restraint in space continue between a status quo power and a rising power?

> *Will this Cold War record of uncommon restraint in space continue between a status quo power and a rising power?*

Caution is warranted before reaching overly optimistic or pessimistic answers to these questions. Conditions have changed, and the competition between Washington and Beijing will be different in crucial respects than that between the United States and the Soviet Union. Besides, there has never been a consensus in the United States over the definition of, and requirements for, successful deterrence. Moreover, Beijing's strategic objectives and the means that will be employed to achieve them remain opaque. What can be said with certainty is that the mix of US-Chinese cooperation and competition in space is not predetermined. Instead, this mix will reflect, and be influenced by, a much larger canvas of bilateral relations.

DETERMINING REQUIREMENTS

The requirements of nuclear deterrence have always been varied and in dispute. Decades of living with and arguing about the "Bomb" have not settled these arguments. The same is likely to be true with regard to the requirements of space deterrence. No one can assert with authority why nuclear deterrence "worked" to prevent battlefield use since 1945. Nor is there a convincing body of evidence whether more or fewer nuclear weapons, at greater or lesser states of operational readiness, whether deployed in different configurations, or whether accompanied by missile defenses, would have made thermonuclear warfare more or less likely. The United States and Soviet Union embraced excessive requirements for nuclear deterrence during the Cold War. Both escaped Armageddon despite or because of these requirements, depending on how dovish or hawkish one's inclinations are.

In the nuclear realm, major debates accompanied the unveiling of the atomic bomb, the hydrogen bomb, the intercontinental ballistic missile, sea-based deterrents, multiple independently targetable reentry vehicles, ballistic missile defenses, and cruise missiles. The sheer intensity and duration of the US-Soviet strategic competition ensured extended debates over the requirements of nuclear deterrence. These debates were intensified further by the advent of negotiations to control and reduce nuclear capabilities, as the pace of strategic modernization programs typically accelerated alongside diplomatic efforts to control the arms race. With the demise of the Soviet Union, domestic debates in the United States now have focused on how low US numbers can safely go, and how nuclear deterrence can best be maintained in an era of deeper reductions.

> *Compared with the nuclear arms competition, strikingly new military developments in space have been rare occurrences.*

Compared with the nuclear arms competition, strikingly new military developments in space have been rare occurrences . Moreover, diplomatic initiatives for space were rare and mostly consensual occurrences, in stark contrast to nuclear arms control and test ban treaties. Consequently, debates over space deterrence and the best ways and means for its promotion have been less intense and less frequent than those over nuclear deterrence. One big exception was the launch of Sputnik, which generated an intense debate over military uses of space and the appropriate US strategic posture. When the Eisenhower, Kennedy and Johnson administrations concluded that US national security was best served by accepting – indeed, seeking to promote – the safe passage of satellites overhead, there was less to debate. A significant diplomatic initiative – the 1967 Outer Space Treaty – set some norms of responsible behavior in space, placed this domain off-limits to weapons of mass destruction, and elicited broad public acceptance. Building on this enduring diplomatic accomplishment, while forging a US consensus on the requirements to deter attacks on national assets and critical infrastructure relating to space, is likely to be more difficult in an era of hyper-partisanship on Capitol Hill.

In the absence of a consensus on the requirements of nuclear deterrence in the United States, decisions on force structure were shaped more by the legacy of prior national decisions, domestic politics and economic constraints than by fresh thinking and clean-sheet-of-paper strategic planning. Notably, steep reductions in US and Russian nuclear arsenals over the past quarter-century have not been accompanied by waves of public anxiety in the United States about the efficacy of nuclear deterrence. While Washington and Moscow continue to have disagreements, it is hard to envision a deep crisis between them that could trigger a crossing of the nuclear threshold.

How much nuclear capability is enough for deterrence elsewhere? The most defensible answer is, “it depends.” Outlier states, such as North Korea, Iraq under Saddam Hussein, and Libya under Muammar Qaddafi, have sought a handful of weapons and the means to deliver them to deter attacks by major powers or to extend freedom of action within their environs. The issue is still joined as to whether Iran falls in this category, or whether Iran’s Supreme Leader would be content with a virtual capability, short of weaponization.

Great Britain and France, major powers possessing legacy arsenals, have the luxury to determine the requirements of nuclear deterrence in fixed terms. These requirements have been shaped by the interplay of symbolism, budgetary pressures, and the presumed value nuclear weapons provide to be “taken seriously” by Washington and the international community.

> *How much capability is enough for deterrence? The most defensible answer is, “it depends.”*

In contrast, India and Pakistan, mid-sized newcomers to the ranks of states possessing nuclear arsenals, have far more pressing security concerns, including territorial disputes, recurring crises and the not-too-distant memory of a limited war occurring shortly after testing nuclear devices in 1998. Matters have been complicated further because of China’s role in assisting the development of Pakistan’s deterrent along with Beijing’s parallel pursuit with New Delhi of more consequential roles in Asia.

Under these circumstances, all three parties in this triangular competition appear to have defined nuclear requirements in relative terms. The annual growth of these arsenals is the most dynamic feature of contemporary nuclear equations. This triangular competition could be heightened by externalities, particularly relating to Washington’s missile defense programs, US defense cooperation agreements with India, and the occurrence of contentious issues with Beijing, including in space. At present, however, the primary drivers of nuclear deterrence requirements reside within the triangle, marked by the diversification of delivery platforms for nuclear weapons to include short-range delivery vehicles, sea-based systems as well as cruise missiles. Much depends on whether Pakistan, the state that can least afford this competition, relaxes its perceived requirements for nuclear deterrence, and whether the two states that can most afford to compete, China and India, choose to buttress their national strength by downplaying the role of nuclear weapons and by focusing primarily on economic growth. If so, their stockpile growth might be far below production capacity.

DETERMINING SUCCESS

Definitions of "successful" nuclear deterrence require clarification and qualification. On two occasions – the Sino-Soviet clash in 1969 and the Kargil conflict in 1999 between India and Pakistan – the possession of nuclear weapons by neighboring states did not prevent border skirmishes and limited wars. Instead, the acquisition of overt nuclear capabilities may actually have emboldened the weaker state to engage in risk-taking of this kind. Nor has the possession of nuclear weapons deterred wars or ensured successful outcomes in wars with non-nuclear-weapon states, including the 1982 war between Great Britain and Argentina; the 1979 border war between China and Vietnam; the US war in Indochina from 1964 to 1973; and wars waged by the Soviet Union from 1979 to 1989 and the United States from 2001 onward in Afghanistan.

The possession of nuclear weapons has not prevented harrowing crises between nuclear-armed states over Cuba in 1962, in the Middle East in 1973, between the US and the Soviet Union in 1983, and between Indian and Pakistan sparked by spectacular acts of terrorism in 2001 and 2008. While consensus is illusive on the role of nuclear weapons in these cases, the preponderance of evidence suggests that nuclear weapons were not useful in compelling an adversary to alter unwanted or harmful behavior during these crises. Nuclear threats by the Eisenhower administration directed against China during the Korean War might be an exception to the above cases. If so, the success was qualified, since US compellent threats appear to have hastened Beijing's acquisition of its own nuclear deterrent.

Despite this historical record, the presumption that deterrence is strengthened by stockpile growth, diversification and dynamism remain strongly held within nuclear enclaves. A contrary view has been offered most persuasively by those who have been tested in the crucible of crises where breakdowns of nuclear deterrence were possible. During severe crises, crisis managers become their own action officers, so very few individuals have been in positions to provide first-hand assessments of how close "successful" nuclear deterrence came to breaking down. From this chastened perspective, the size and war-fighting characteristics of opposing arsenals has mattered less than preventing even a single nuclear detonation in times of deep crisis.

The Cuban missile crisis is, thus far, the most harrowing and carefully researched case study on the limited utility of nuclear weapons in deep crisis. McGeorge Bundy, President John F. Kennedy's national security advisor, famously reflected on these matters seven years afterward:

It is one thing for military men to maintain our deterrent force with vigilant skill, and it is quite another to assume that their necessary contingency plans have any serious interest for political leaders. The object of political men – quite rightly – is that these weapons should never be used. … Political leaders, whether here or in Russia, are cut from a very different mold than strategic planners. They see cities and people as part of what they are trying to help – not as targets.[6]

Nikita Khrushchev arrived at much the same conclusion in his memoirs. Khrushchev concluded that, "Any fool can start a war, and once he's done so, even the wisest of men are helpless to stop it—especially if it's a nuclear war."[7] His thinking mirrored Bundy's: "I knew that the United States could knock out some of our installations [in Cuba], but not all of them. If a quarter or even a tenth of our missiles survived—even if only one or two big ones were left—we could still hit New York, and there wouldn't be much of New York left."[8] His bottom line was that "both sides showed that if the desire to avoid war is strong enough, even the most pressing dispute can be solved by compromise … The episode ended in a triumph of common sense."[9]

There is no reason to believe that other US and Soviet leaders would have shared Bundy's and Khrushchev's views had they been handling the Cuban missile crisis. Nor can we assume that their instincts would apply to contemporary national leaders in China, India and Pakistan if faced with the same crucible of decision. And yet, the "enormous gulf" that Bundy witnessed first-hand during the Cuban missile crisis – the "gulf between what political leaders really think about nuclear weapons and what is assumed in complex calculations of relative 'advantage' in simulated strategic warfare"[10] – remains as true today as was the case then. Bundy characterized those seeking added targeting and use options for nuclear weapons – as is now evident in China, India and Pakistan – as living in an "unreal world":

In the real world of real political leaders … a decision that would bring even one hydrogen bomb on one city of one's own country would be recognized in advance as a catastrophic blunder; 10 bombs on 10 cities would be a disaster beyond history.[11]

In Bundy's view, successful nuclear deterrence is not about seeking relative advantage or disadvantage. It's not about the quest for superiority, and it's not about nuclear war-fighting scenarios. Other notable US strategists, such as Paul Nitze, held diametrically opposite views. Regardless of their differences, men like Bundy and Nitze could agree that nuclear deterrence was necessary and conducive to restraint in deep crisis. Above all, successful nuclear deterrence was – and is – about not crossing the nuclear threshold.

The recollections of Khrushchev and Bundy constitute a very small but significant sample that force size was not determinative in the outcome of the Cuban missile crisis. The United States held an overwhelming edge in nuclear capability; indeed, this edge was one reason for Khrushchev's gamble to place Soviet nuclear weapons and their means of delivery in Cuba. Nonetheless, those with powers of decision did their utmost to avoid crossing the nuclear threshold. To those responsible for decision making, the prevention of one nuclear detonation mattered more than the imbalance in nuclear forces.

By logical extension, one can argue that a mutual desire to avoid nuclear exchanges makes an imbalance of conventional capabilities even more consequential in a deep crisis or in warfare. The two limited wars between nuclear-armed states after the Cuban missile crisis point to this hypothesis: the United States enjoyed overwhelming advantages in conventional capabilities in the Caribbean, and the Soviet Union possessed far more conventional firepower and logistical capability than the People's Republic of China, which was reeling from the Cultural Revolution in 1969. India was initially disadvantaged during the Kargil War, but was quickly able to mobilize advantageous conventional capability to the front. The 2001-2 "Twin Peaks" crisis between India and Pakistan, sparked by an attack on the Indian Parliament by militants trained in Pakistan, did not result in limited warfare, in large part because Indian decision makers did not have favorable military options after the Pakistan Army mobilized to block Indian Army offensives.

This cautionary and fortunately limited historical record indicates that fearsome weapons that political leaders do not wish to use provide few advantages in crises and limited wars. Nuclear weapons do have inherent powers to dissuade leaders from taking military action, but the disposition of conventional forces near potential fighting corridors can produce the same result. Political leaders have not found the size of their nuclear arsenals or their war-fighting potential comforting in deep crises. Neither has the possession of a nuclear deterrent been helpful for compellence, nor for avoiding defeats in conventional wars. Instead, the possession of offsetting nuclear weapons has made crises and limited wars especially nerve-wracking, despite the best efforts of national leaders to avoid crossing the nuclear threshold. Some crisis managers have been emboldened by having greater nuclear war-fighting capabilities than an adversary, but their sense of martial conviction was notably absent among those responsible for determining whether to cross the nuclear threshold.

Academic debates over this conclusion have not been entirely settled. One recent analysis by Matthew Kroenig concludes that, "States that enjoy nuclear superiority over their opponents are more likely to prevail in nuclear crises. … Nuclear superiority aids states in games of nuclear brinkmanship by increasing their levels of effective resolve." [12] The hazards of Kroenig's assessment are evident in his conclusion that the outcome of the 1999 Kargil crisis was due in part to India's advantageous strategic force posture. In actuality, Pakistan had a greater capability to deliver nuclear weapons than India during the crisis but was diplomatically isolated and conventionally disadvantaged.

While the size and features of a nuclear deterrent matter less than the possession of "the bomb" and its assured means of delivery, this does not mean that size is completely irrelevant. Size may be one of many other reasons that induce national leaders to exercise caution in deep crises. A small, survivable nuclear arsenal might also be sufficiently persuasive as a deterrent – but this, too, is a supposition, not a certainty. In the case of severe crises between Pakistan and India after both countries demonstrated their nuclear deterrents in 1998, Indian leaders acted with restraint. They did so, in part, because economic growth rates were more important than responding militarily to mass-casualty assaults and, in part, because of the absence of targets in Pakistan that were both meaningful and not likely to prompt unwanted escalation. Despite these qualifiers, national leaders usually opt for more and better nuclear capabilities after a severe crisis. The equation of more nuclear might with greater security has become a bedrock belief within nuclear enclaves — even though the more nuclear-armed adversaries compete, the less secure they feel.

Despite – or because of – the uncertainties noted above, these cases point in the direction of a narrow conception and definition of successful nuclear deterrence. One measure of success can be defined as inducing cautionary behavior between nuclear-armed adversaries. Caution is of great value in avoiding crises, and it is of greater value in the event that crises cannot be avoided. Caution is most valuable when nuclear-armed states engage in limited warfare. Nuclear deterrence succeeds most clearly when adversaries avoid crossing the nuclear threshold. The exercise of caution during severe crisis and limited hostilities as well as avoiding a crossing of the nuclear threshold have become the core definitions of successful nuclear deterrence during and after the Cold War. These core definitions of success, while greatly circumscribed, remain immensely important.

Since the relationship between nuclear force size and the promotion of cautious behavior cannot be proved, proponents and opponents of nuclear weapons can continue to adhere firmly to contrary articles of faith. Those who view the value of nuclear deterrence expansively share a common assumption that more capability equals more advantage – especially when an adversary is engaged in a nuclear build-up. In this view, the more foreboding the edifice of deterrence looks, the less inclined an adversary will be to cross red lines. Consequently, nuclear-armed states concerned about surprise attack and rapid escalation reject constructs of minimum or finite deterrence in favor of additional targeting and use options. Those who ascribe limited value to nuclear deterrence argue that greater targeting and use options place greater stress on command, control, safety and security in times of crisis.

While these debates haven't been resolved, skeptics appear to have the better argument by focusing on one of the many paradoxes associated with nuclear deterrence: immediately below the meta-level that defines success lie conditions for its potential failure. During crises, when nuclear capable forces are readied for use, the possibilities for inadvertent use, breakdowns in command and control, and accidental use grow. Because diversified use options distribute weak points within the edifice of deterrence as it grows, crisis and deterrence stability grow shakier as a result. These dynamics were present during the Cold War superpower competition, and they are present on a far smaller scale in the crisis-prone relations between India and Pakistan.

Severe crises and limited wars clarify the limits and the requirements of successful nuclear deterrence established during the Cold War. Deterrence that succeeds "only" in preventing a crossing of the nuclear threshold succeeds greatly, even if nuclear weapon holdings do not succeed in compelling desired behavior or in altering the course of limited conflict. Because the primary threats to successful nuclear deterrence relate to accidents and loss of control in deep crisis, three operational requirements for successful nuclear deterrence are of overriding importance: secure second-strike capabilities, effective command and control mechanisms over the use of nuclear weapons, and effective safety and security mechanisms to prevent accidental as well as unauthorized use.

> *three operational requirements are of overriding importance: secure second-strike capabilities, effective command and control mechanisms, and effective safety and security mechanisms to prevent accidental as well as unauthorized use.*

The assurance of devastating retaliation, provision of effective command and control, and maintenance of safety and security measures can be costly and complex, but they do not require huge edifices of deterrence based on widely diversified targeting and use options. "Deterrence," as Kenneth Waltz concluded,

> *is easier to contrive than most strategists have believed. … If one thinks of strategies as being designed for defending national objectives or for gaining them by military force and as implying a choice about how major wars will be fought, nuclear weapons make strategy obsolete."* [13]

On this last point, Sir Lawrence Freedman arrived at a similar conclusion – that the term "nuclear strategy" was a contradiction in terms.[14]

EXTRAPOLATING TO CHINA AND TO SPACE DETERRENCE

The United States maintains a great many nuclear weapons and diverse means for their delivery to deter a similarly armed and similarly vulnerable adversary. This force posture was sized in comparison with the Soviet Union during the Cold War and subsequently to the Russian Federation. Force sizing to deter the Kremlin appears sufficient for all lesser cases, including the objective of dissuading the People's Republic of China from seeking to compete with the United States in this realm. US nuclear forces continue to be maintained in a high state of readiness – albeit not as high as during the Cold War – to deter surprise attack and to provide the National Command Authority with prompt and varied options in the event of a breakdown in nuclear deterrence.

In contrast, the requirements to deter attacks on US space assets, at present, do not appear to include kinetic-energy weapons dedicated to space deterrence that are deployed in space, on land or at sea. Dedicated ASAT weapon systems were considered deployed for portions of the Cold War, but they were rudimentary and poorly suited for operational requirements. They were not replaced, systematically upgraded and repeatedly tested to demonstrate vigilance, resolve and to reinforce deterrence , as was the case for nuclear weapons and their means of delivery.[15]

> *Dedicated ASAT weapon systems were rudimentary and poorly suited for operational requirements. They were not replaced, systematically upgraded and repeatedly tested to demonstrate vigilance, resolve and to reinforce deterrence*

The Soviet Union possessed far more formidable military space and nuclear capabilities than the People's Republic of China does now. The United States engaged in minimal commerce with the Soviet Union, compared to significant trade and financial interactions currently with China. The Cold War contest between the United States and the Soviet Union was ideological, global and geopolitical. In contrast, the competition between the United States and China lacks an ideological dimension and is, at present, more regional than global. These contrasts suggest that the relatively relaxed US-Soviet military competition in space might carry forward in a competitive relationship between the United States and China. On the other hand, Beijing's intentions and ambitions are unclear, and bilateral cooperation in space between the United States and China is minimal compared to the US-Soviet and US-Russian experience.

There can be no doubt that space has become, as the Obama administration has noted repeatedly, more competitive, contested and congested than during the Cold War.[16] Features of space operations have changed markedly, including the advent of commercial space operations and profit-taking related to satellites, the increase in the number of nations utilizing space for varied purposes, and the criticality of space systems for military operations. All major space-faring nations increasingly rely on satellites, but none more so than the United States. Multinational partnerships in space now figure prominently; the sharing of benefits and risks might alter deterrence calculations, as well. All of this, and more, is significantly different from the first three decades of the Space Age. Does this mean that Cold War-era calculations of the requirements for space deterrence have fundamentally changed?

> *attacks on critical assets and infrastructure in space commonly were viewed in the gravest terms, regardless of whether they were precursors to attacks on nuclear forces*

To answer this crucial question, we must first try to reach an informed judgment as to why the requirements for space deterrence were presumed to be so different from nuclear deterrence during the Cold War, and then to assess whether these conditions remain in place. One possible reason is that major powers have long considered warfare in space to be linked to nuclear warfare. If so, the requirements of the former might have been subsumed in the latter. The linkages between nuclear warfare and activities in space are numerous and well understood. Satellites are connected in many ways to the execution of nuclear war-fighting plans by helping with weather forecasting; targeting, indications and warning of attacks; assessing damage and maintaining command, control and communications. During the Cold War, the contestants understood that to disable or attack these satellites by whatever means was unlikely to be viewed in a vacuum. Instead, attacks on critical assets and infrastructure in space commonly were viewed in the gravest terms, regardless of whether they were precursors to attacks on nuclear forces . These conditions continue to remain in place.

An appreciation of the linkages between space assets and nuclear assets does not, however, explain why nuclear tests were so prevalent and why ASAT tests were so limited during the Cold War. Despite the clear linkages between nuclear and space deterrence, requirements for the former were excessive and requirements for the latter were relatively relaxed. As noted earlier, this dichotomy can probably be explained, in some measure, by the abundance of other means to interfere with, damage or destroy critical assets in space, including non-kinetic kill mechanisms such as lasers and jammers. Counter-space capabilities reside in conventional- and nuclear-armed weapon systems, including missiles of various kinds, along with missile defense interceptors. The perceived requirements for dedicated systems to engage in space warfare might well have been reduced significantly because of these residual or latent capabilities. These conditions remain in effect. Indeed, latent capabilities to engage in space warfare have grown, and have become more prominent because missile defense interceptors have been tested dramatically in an ASAT mode by China in 2007 and by the United States in 2008.

> *latent capabilities to engage in space warfare have grown, and have become more prominent*

A third possible explanation for Cold War restraint – albeit one that has become far more appreciated of late – might relate to the indiscriminate, abhorrent and self-defeating nature of some means to engage in warfare in space. This first became apparent with respect to atmospheric nuclear testing. These tests generated public revulsion and political activism. By the early 1960s, concerns over public health dangers arising from atmospheric tests overrode the arguments of those who desired their continuation to clarify military and operational requirements. Less well known were the potential hazards of atmospheric tests to the health of the first astronauts and cosmonauts, as well as to the first satellites placed in low Earth orbit. One particularly powerful US test on July 9, 1962, Starfish Prime, damaged at least six fledgling satellites.[17]

Space debris poses a clear and present danger in space analogous to the danger atmospheric testing posed to satellites and human exploration at the dawn of the space age. The hazards of ASAT tests involving "hit-to-kill" technologies first became apparent during the Cold War, when a 1985 US ASAT test created over 250 pieces of trackable space debris, one of which came within one mile of the newly launched international space station 14 years later. The abhorrent, indiscriminate and self-defeating consequences of debris-causing ASAT tests were not widely appreciated during the Cold War because few of these tests were carried out.[18]

A kinetic-energy ASAT test conducted in 2007 by the People's Liberation Army (PLA) ended complacency over the hazards of space debris. This ASAT test produced more than 3,000 pieces of debris large enough to track, and tens of thousands of smaller pieces, endangering human spaceflight and hundreds of satellites, without regard for ownership and nationality.[19] The Pentagon demonstrated an agile, sea-based ASAT capability in 2008 by shooting down a non-functioning intelligence satellite, in a manner that minimized debris consequences. As a result of these tests, as well as other significant debris-causing events, recognition of the potential environmental consequences of space warfare is unquestionably greater now than during the Cold War. Reaction to the PLA's 2007 ASAT did not spark mass protests, unlike the case of atmospheric testing. This ASAT test did, however, alarm space operators to such an extent that an international norm against further tests of this kind might take hold.

> *Space debris poses a clear and present danger in space analogous to the danger atmospheric testing posed to satellites and human exploration at the dawn of the space age*

While the fragility of the global commons might induce restraint with regard to kinetic-energy ASATs, there are other means to interfere with and damage satellites. As noted above, lasers and jammers could also be employed to disrupt space operations, and could do so without creating debris fields. In this event, one critical element of space deterrence, as with nuclear deterrence, is the ability to determine who has sought to damage space assets, or succeeded in doing so, by non-kinetic means.

> *Attribution is a critical prior step to the choice of retribution.*

Attribution is a critical prior step to the choice of retribution. The attribution problem is likely to be harder with regard to space warfare, if for no other reason than the list of potential suspects is longer, including perpetrators that may not be under the control of governments.[20] The attribution problem is, however, not unique to space warfare; it also applies to acts of terrorism, including nuclear terrorism. One means of deterrence across domains is the distribution of varied means of observation: some perpetrators might not carry out hostile acts if they have reason to expect discovery. Thus, redundant means of space situational awareness can serve deterrent purposes. Similarly, the development of forensic capabilities to attribute responsibility backs up deterrence across domains, but is likely to be more difficult in space, where physical evidence cannot be examined properly. In all domains, the context within which hostile actions are taken is likely to be strongly suggestive of the perpetrator, but may not be definitive.

Another common aspect of nuclear and space deterrence is the requirement for resilience.[21] The value of any attack on space assets diminishes in proportion to the victim's ability to compensate, recoup losses and respond appropriately. Deterrence against limited attacks, including attacks by non-kinetic means, is thereby reinforced by the evident ability to adjust to disruptions and losses of capability. Limited attacks and disruptions might well be more likely in asymmetric warfare than in confrontations between major powers because the weaker party can expect to have less to lose in space warfare. At the same time, the weaker party might have insufficient means to disrupt the space operations of the dominant power – except by using nuclear detonations that would badly affect space assets of all major powers. Outlier states might have few friends, but they are unlikely to want to alienate them by disrupting their space operations.

> *the worst case of a "space Pearl Harbor" has displaced Cold War concerns over a disarming "bolt-out-of-the-blue" attack against US nuclear forces*

Worst-case projections of a failure in space deterrence – as with the worst case projection of a failure of nuclear deterrence – involve catastrophic losses from a surprise attack. For some, the worst case of a "space Pearl Harbor" has displaced Cold War concerns over a disarming "bolt-out-of-the-blue" attack against US nuclear forces . Only major powers have the capacity for massive attacks against a wide range of space assets in low Earth and geosynchronous orbits, as well as in between. The most persuasive deterrent against the low probability, but high-consequence nature of worst cases is the evident ability to respond with devastating effect to grievous injury. In the worst case of a bolt-out-of-the-blue, massive nuclear attack, deterrence was reinforced by clarifying the degree of difficulty for the attacker's success and the horrific consequences of failure.

The worst case of a bolt-out-of-the-blue nuclear attack postulates that a nuclear response would cause insufficient retribution, or might be withheld to avoid even more fearsome punishment. Those who focus on the worst case of a breakdown in space deterrence argue that the aggressor has a greater likelihood of success than with a surprise nuclear attack, and that the victim will be reluctant to respond by crossing the nuclear threshold. While worst cases lie on the improbable end of the spectrum of possibilities, they cannot be ignored. US and Soviet leaders spent excessive amounts of money and deployed improbable numbers of nuclear weapons to guard against worst cases. The resulting nuclear force postures built to deter bolt-out-of-the-blue attacks were not very reassuring. To the contrary, the buildup of nuclear war-fighting capabilities to deal with worst cases raised insecurity. In a far more constrained budgetary environment, US national leaders must decide now how much of a deterrence and insurance policy to buy against a low probability/high consequence scenario of a massive surprise attack in space.

A severe crisis between major powers that plays out in space will reflect the magnitude of the stakes involved – a space age Cuban missile crisis . National leaders contemplating the first move of space warfare will face the same unalterable dilemmas of choice that Kennedy and Khrushchev faced. A leader can choose limited warfare for extremely uncertain gains and the possibility of uncontrolled escalation, or seek victory with the potential of all-out warfare and devastating consequences.

> *A severe crisis between major powers that plays out in space will reflect the magnitude of the stakes involved – a space age Cuban missile crisis*

In the first-ever severe crisis between major powers in space, both contestants will possess the capacity to deny each other's pursuit of space dominance. In this way, the nature of the space domain, where offense easily trumps defense, is like the nuclear domain. Consequently, the contestants will be unable confidently to ensure decisive victory by means of surprise attack. Just as protection from fallout in nuclear exchanges cannot be secured, so, too, will the first use of kinetic-energy ASATs be self-denying: mutating debris fields will make large swaths of space inoperable to one's own satellites, either quickly or over time. The use of non-kinetic-energy ASATs on a modest scale invites retaliation in kind or retaliation across domains. The use of non-kinetic-energy ASATs on a massive scale invites massive retaliation, if not in kind, then across domains. In the event of a severe crisis between Washington and Beijing, would a Chinese leader risk everything with this cosmic throw of the dice?

In the event of warfare in space between major powers, national leaders will face an abundance of risk, just as they would in the event of warfare on the ground or at sea. The presumption inherent in worst case projections of space warfare is that disabling violence in space will dissuade conventional military responses and will not spill over to nuclear warfare. This assumption of compartmentalization weakens deterrence in all domains. The "space Pearl Harbor" scenario also assumes that warfare in space, unlike warfare in other domains, can be executed without unwelcome surprises, miscalculations, accidents or breakdowns in command and control.

US and Soviet leaders did not presume this to be the case during the Cold War, and US and Chinese leaders need not presume this to be the case in the future. The conclusion reached by Kurt Gottfried and Richard Ned Lebow during a dark Cold War chapter of heightened military competition in space seems equally relevant in a US-China context: "ASATs possess a considerably greater capacity for transforming a crisis into a war, and for enlarging wars, than they do for assisting in military missions or enhancing deterrence."[22] This conclusion seems equally applicable to space warfare by kinetic or non-kinetic means. With the benefit of hindsight, concerns over the worst case of a bolt-out-of-the-blue nuclear attack now seem quite overdrawn. While military plans to execute this scenario existed, political leaders sought to avoid executing them. Worst case assessments of a space Pearl Harbor seem unlikely, as well.

If a breakdown in space deterrence occurs, it could be as a result of seeking tactical advantage in conjunction with limited military operations. Alternatively, a breakdown of space deterrence could be a defensive act for signaling purposes, as has often been postulated with a breakdown of nuclear deterrence. In either case, deterrence breakdowns are most likely to happen on a limited scale alongside attempts to maintain, as much as possible, the military use of space. While worst-case scenarios appear implausible, there may well be a greater potential ambit for limited warfare in space, since satellite interference and disruption can be reversible. The requirements to shore up deterrence or to compensate for a breakdown of deterrence in these scenarios are far more modest than the requirements to deal with worst cases.

> *the notion of "cross-domain" deterrence is not inherently unique or distinct to this domain.*

Breakdowns of space deterrence could also take the form of attacks on ground-based critical infrastructure, whether by non-state actors, special operation forces, air strikes or by other means. Attacks on the US homeland or on US installations abroad could reasonably be expected to prompt retaliation of a kind and intensity deemed justified by US leaders. Responses might be proportionate or disproportionate to the damage incurred. In these scenarios, a wide range of military options would be at the disposal of US leaders. In this sense, the notion of "cross-domain" deterrence, which is often discussed as having special relevance to space, is not inherently unique or distinct to this domain. No country enjoys a wider range of choice to reinforce deterrence than the United States. Retaliation in kind has always undergirded deterrence in the nuclear domain, but US decision makers have never been obliged to respond in kind and in the same domain with regard to hostile actions not involving nuclear weapons.

The common thread running through this wide range of contingencies is the difficulty US decision makers will face in deciding on appropriate responses while maintaining escalation control. In deep crises between major powers, deterrent capabilities will be tested not just against each other, but against the ability of national leaders to keep events in harness. The great edifices of nuclear deterrence constructed during

> *In deep crises between major powers, deterrent capabilities will be tested not just against each other, but against the ability of national leaders to keep events in harness.*

the Cold War had built-in weaknesses – far less against surprise attack than against maintaining command and control over battlefield and accidental use. The same conditions might well apply to space, where the edifices of deterrence have been inferential and modest. Because severe crises in space, unlike deep crises associated with offsetting nuclear arsenals, have yet to occur, weaknesses in systems of space deterrence have not been tested fully and may be poorly understood. Deterrence capabilities will always look better in the abstract than in the crucible of decision making after deterrence fails. Resilient and redundant capabilities in space are helpful, to the extent that they are affordable, to convey deterrence messages. The message of cross-domain deterrence may also be helpful, but does not make decision making any easier in the event of a breakdown in deterrence.

FUTURE PROSPECTS

This 2007 Chinese ASAT test, like the launch of Sputnik 50 years earlier, has sparked debates over the preferred mix of competition and cooperation in space between major powers. The US debate over Sputnik was not answered definitively and was revisited at particularly harsh junctures during the Cold War. The 2007 Chinese ASAT test clarified, if further clarification were needed, the choices under consideration. The fragility of operations in space offers the possibility of a shared understanding among major space-faring nations to cooperate in protecting and utilizing this domain. This hopeful hypothesis has always coexisted with justifiable reasons for pessimism. Capabilities to carry out warfare in space are growing and have never been greater. As was the case during the Cold War nuclear competition, the growth of war-fighting capabilities can be unnerving as well as deterring.

Major powers in the nuclear age have managed so far to cooperate as well as compete. They can do so in space, as well. Nuclear diplomacy is commonplace, while space diplomacy has been pursued rarely. Nuclear competition is usually ramped up alongside diplomatic efforts. To a lesser extent, this has been true for space diplomacy. This was evident prior to and during the brief period of ASAT talks during the administration of President Jimmy Carter. It is also evident at present, when Washington, Moscow and Beijing are championing quite different diplomatic initiatives. In the vacuum created by the Bush administration's withdrawal from the Anti-Ballistic Missile Treaty, Russia and China have promoted a treaty to ban the use of force and weapons in outer space. The United States, the European Union and Japan favor an International Code of Conduct for space. The Russian and Chinese approach, calling for an unverifiable, Kellogg-Briand-like, hortatory treaty, is neither feasible nor advisable. By comparison, an International Code of Conduct has practical, near-term potential to establish and strengthen norms for responsible behavior in space. These diplomatic initiatives have been punctuated by rare displays of hit-to-kill ASAT capabilities.

> *While the concurrency of diplomatic initiatives and heightened military competition is not new, widespread recognition of the precariousness of space as a global commons is a relatively recent phenomenon.*

While the concurrency of diplomatic initiatives and heightened military competition is not new, widespread recognition of the precariousness of space as a global commons is a relatively recent phenomenon. The prevalence and dangers of space debris in low Earth orbit factors into space deterrence calculations in ways that have yet to be appreciated widely. Deterrence is reinforced when a particular means of warfare is commonly viewed as self-defeating – even when an adversary takes no action in response. Deterrence is also reinforced when a particular means of warfare is commonly viewed as being likely to result in unwanted and uncontrolled escalation. Kinetic-energy ASATs qualify on both counts. Their use would be self-defeating in the sense that the resulting debris can place one's own satellites and space operations at risk. Moreover, the pinball effects of mutating debris fields increase the likelihood of uncontrolled escalation in terms of additional damage accruing to satellites from follow-on debris hits. If these phenomena are well understood, deterrence against kinetic-energy warfare in space is greater now than ever before.

Kinetic acts of warfare between major powers directed at space assets on the ground pose a significant likelihood of prompting unwanted or uncontrolled escalation of a different kind. The United States and the Soviet Union experienced severe crises during the Cold War, playing with fire in Berlin and Cuba, as well as in the eastern Mediterranean, where naval forces operated in close proximity during the 1973 crisis in support of friendly governments in the Middle East. After these extremely tense encounters, both nuclear superpowers continued to jockey for geopolitical advantage, but did so by employing proxies and by taking advantage of each other's missteps in locales peripheral to supreme national interests. In all of these cases, the United States and the Soviet Union avoided the direct use of force, knowing that kinetic engagements could spiral out of control and that a crossing of the nuclear threshold might lead to uncontrollable events.

During the Cold War and immediately after, the scenario of a direct clash between the United States and China that seemed most worrisome involved Taiwan. This scenario remains possible, but is widely regarded as being less likely due to the extent of trade and investment between Taipei and the mainland. If this assessment proves to be correct, it has important relevance to the prospect of warfare in space or on the ground between the United States and China. Trade and financial interactions between the United States and the People's Republic of China (PRC) are significant and growing. If nuclear deterrence constitutes a mutual hostage relationship, the same dynamic applies to nuclear-armed states that engage in activities that shore up each other's national economy. The Soviet Union and the United States engaged in one mutual hostage relationship, but not the other. The PRC and the United States engage in not one, but two, mutual hostage relationships. The combination of nuclear deterrence and economic co-dependency suggests that acts of warfare in space can be deterred, and that the requirements to do so might not be more onerous than during the Cold War, when economic co-dependency did not accompany nuclear deterrence.

Of all the Cold War cases, the 1973 crisis in the eastern Mediterranean might have the most relevance to contemporary concerns of a clash between the United States and China. To be sure, analogizing from the 1973 Middle East crisis requires many qualifiers. China, unlike the Soviet Union and the United States in 1973, has no close friends to protect from offshore. Unlike the Soviet Union (and Russia at present), Beijing has not extended help to friendly countries that have found themselves in trouble of their own making. For example, China's "all-weather" friend, Pakistan, has reached out to Beijing for help during severe crises with India, and Pakistani leaders have returned home empty handed in each case.

Despite these and other differences, the 1973 crisis and a potential clash between the US and Soviet navies in the eastern Mediterranean still resonates with respect to US-

China relations. There are territorial disputes between Beijing and US friends and allies in the East China and South China seas. Beijing has upgraded its declared national interests in these territorial disputes, and is extending the reach of its naval capabilities. As Michael Nacht has noted, both Washington and Beijing embrace anti-access, area denial military strategies, although US capabilities are not described as such.[23] This, together with asymmetrical capabilities and interests, could well lead to friction in space, on the ground and, especially, at sea.

The explosive potential of a clash at sea between the US and Chinese navies has now eclipsed prior concerns regarding Taiwan. During the Cold War, the United States and the Soviet Union both pursued anti-access, area denial strategies and capabilities. Moreover, Washington and Moscow possessed asymmetric capabilities and interests, no less than is currently the case between the United States and the PRC. And yet, the very circumstances that have led some to conclude that warfare in space between the United States and China is inevitable did not result in warfare in space, on the ground, or at sea between the United States and the Soviet Union.

The primary distinction between these two cases is the absence of commerce with a Cold War adversary and the prevalence of economic competition and co-dependency with China. In the view of space deterrence pessimists, warfare typically follows commerce. As the 2001 Space Commission report chaired by Donald Rumsfeld, who was soon to become US secretary of defense, argued, "The political, economic and military value of space systems makes them attractive targets for state and non-state actors hostile to the United States and its interests."[24] Skeptics of space deterrence are arguing, in effect, that advantages in military space capabilities matter greatly, while significant US advantages in nuclear and conventional forces may have insufficient deterrent effect.

> *Military plans are not determinative. Clashes between major powers have become rare by historical standards, especially since the advent of nuclear weapons and satellites*

These skeptics reinforce their case on the shaky ground of historical inevitability. As the 2001 space commission chaired by Donald Rumsfeld concluded, "We know from history that every medium—air, land and sea—has seen conflict. Reality indicates that space will be no different."[25] There is, however, no historical inevitability associated with matters of war and peace in the nuclear and space age. Those offering the words "history proves" are rarely historians. As Bernard Brodie – a naval historian by training – has wryly noted, “When one hears the phrase ‘history proves’ one should get ready for bad history and worse logic.” [26] It is as hazardous to argue the future inevitability of warfare between the United States and China as it was to assert the inevitability of warfare between the United States and the Soviet Union during the Cold War. Military plans are not determinative. Clashes between major powers have become rare by historical standards, especially since the advent of nuclear weapons and satellites . Friction between the United States and China resulting from economic competition is far more likely to result in protective tariffs than in warfare.

A space Pearl Harbor – to borrow once more from the 2001 Rumsfeld space commission report[27] – is possible, just as a massive surprise attack with nuclear weapons has always been possible. But neither is probable as long as the basic requirements of space deterrence, as with nuclear deterrence, are met. Cold War history was studded with crises and the occasional proxy war, but no instances of direct conflict between the United States and the Soviet Union. In large measure, most historians and strategists attribute this surprising fact partly to offsetting nuclear weapon capabilities. To dismiss the argument of historical inevitability is not, therefore, to dismiss the value of deterrence. Deterrence helped to avoid nuclear exchanges and warfare in space between two superpowers inclined toward the status quo after their searing crises over Berlin and Cuba. This record of accomplishment can also extend to competition between a status quo power and a rising power – and with far less onerous deterrence requirements.

CONCLUSION

The US dependency on space will grow as Chinese military space capabilities grow. As a consequence, the United States is obliged to reinforce space deterrence capabilities while engaging in diplomatic initiatives aimed at reassurance . This combination of initiatives proved successful during the Cold War, and can continue to be successful in the future.

> *successful deterrence requires situational awareness, attribution capabilities, as well as resilient space assets*

The key elements of space deterrence, as with nuclear deterrence, are secure retaliatory capabilities sufficient to deny advantages to an attacker, effective command and control mechanisms, and redundant safety and security mechanisms to prevent accidental as well as unauthorized use of military capabilities. In addition, successful deterrence requires situational awareness, attribution capabilities, as well as resilient space assets so that the United States is able to identify the perpetrator of harmful actions and continue to utilize space for national and economic security despite these acts.

These requirements are not controversial, although they may not be affordable in sufficient measure – as was the case with the perceived requirements of nuclear deterrence. The crux of debate over space deterrence is whether to continue to rely very heavily on latent or residual capabilities to engage in warfare, if necessary, or to shift toward more evident, dedicated, kinetic and deployed means of dissuasion. There are several powerful arguments for the United States to continue to rely on inferred rather than heavily demonstrable deterrence in space. To begin with, a non-dedicated, non-deployed, non-kinetic space deterrence posture has been successful in the past. An inferred posture is also more conducive to stabilizing deterrence than the deployment and testing of dedicated, kinetic counter-space capabilities. These hallmarks of an intensified arms competition did not produce a great sense of security in the nuclear domain, and are unlikely to offer a greater sense of security in space. Instead, more demonstrable space deterrence efforts are likely to increase requirements and costs while decreasing assurance.

An accelerated competition in the development, testing and deployment of US and Chinese counter-space capabilities is likely to spill over into the nuclear domain. The practical effect of this linkage would be to increase nuclear requirements in China, while retarding reductions in deployed US nuclear capabilities that are in excess of the Pentagon's needs. In a constrained budget environment, the United States could apply defense dollars more wisely and enjoy added security if this dynamic could be avoided. Another reason to avoid an intensified competition in dedicated and deployed counter-space capabilities is that residual and latent US counter-space capabilities are growing significantly, particularly with respect to new missile defense interceptors. The growth in inferred capability provides the basis to avoid a competition in dedicated, deployed counter-space capabilities – if China is amenable to inferential deterrence.

This is an essential qualifier. A continued US preference to avoid a heightened competition marked by repeated displays of dedicated capability to disrupt, damage or destroy space assets depends on Beijing's acceptance of inferred deterrence. The United States and China have both demonstrated counter-space capabilities. If Beijing decides to ramp up its space warfare capabilities, the Pentagon will not be found wanting in this competition. A far more preferable posture would be one of "contingent restraint," whereby the Pentagon does not exercise options well within its capabilities, as long as the PLA is similarly constrained. Parallel policies of contingent restraint worked during most, but not all, intervals of the Cold War.[28] This dynamic can also succeed under far less demanding contemporary circumstances.

Deterrence is based on threats. Deterrence, by itself, is not reassuring. The Cold War did not become hot because deterrence was complemented by reassurance in the form of diplomatic accords to reduce nuclear dangers. Contingent restraint can be inferential, or it can be reinforced by diplomatic accords. Stable deterrence requires reassurance when competitors possess devastating military options.[29]

> *If Beijing decides to ramp up its space warfare capabilities, the Pentagon will not be found wanting in this competition. A far more preferable posture would be one of "contingent restraint"*

Washington and Beijing have yet to demonstrate successful diplomatic engagement to moderate a military competition in space. Neither have they agreed on cooperative joint ventures in space, like those that helped diminish pressures to ramp up US and Soviet space warfare requirements during the Cold War. Reassurance during the Cold War took the form of treaties. Senate consent to, and the entry into force of treaties regarding military space capabilities seem unlikely. Executive agreements remain possible, however. One means of reassurance – an International Code of Conduct for responsible space-faring nations – is readily available. Another, in the form of collaborative ventures in space science and exploration, awaits the commitment of far-sighted leaders.[30]

Worst-case projections related to nuclear warfare between the superpowers – projections that led to massive nuclear stockpiles – did not carry over to Cold War preparations for warfare in space. Most analysts, whether optimistic or pessimistic by nature, were pleasantly surprised by this result. Under quite different and less challenging circumstances, a dangerous military competition in space between the United States and China might also be avoided by combining deterrence with reassurance.

1. For first cuts assessing space deterrence, see Forrest E. Morgan, *Deterrence and First-Strike Stability in Space: Preliminary Assessment* (Santa Monica, Calif.: RAND Corp., 2010); Roger G. Harrison , Collins G. Shackelford and Deron R. Jackson, "Space Deterrence: The Delicate Balance of Risk," *Space and Defense* 1 no. 3 (2009): 1-30; and Forrest E. Morgan et al., *Dangerous Thresholds: Managing Escalation in the 21 st Century* (Santa Monica, Calif.: RAND Corp., 2008).
2. For more on this period, see Walter A. McDougall, *… the Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985); John M. Logsdon, *John F. Kennedy and the Race to the Moon* (New York: Palgrave Macmillan, 2010); James Clay Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests* (Palo Alto, Calif.: Stanford University Press, 2008); and William E. Burrows, *This New Ocean* (New York: Random House, 1998).
3. For more on ASATs during the Cold War, see Paul B. Stares, *The Militarization of Space: U.S. Policy, 1945-1984* (Ithaca, N.Y.: Cornell University Press, 1985); Paul B. Stares, *Space and National Security* (Washington: The Brookings Institution, 1987); William J. Durch, *National Interests and the Military Use of Space*, (Cambridge, MA: Ballinger, 1984); "Weapons in Space, Vol. I: Concepts and Technologies," *Daedalus* 114, no. 2 (Spring 1985) and "Weapons in Space, Vol. II: Implications for Security," *Daedalus* 114, no.. 3: (Summer 1985); Steven Weber and Sidney D. Drell, "Attempts to Regulate Military Activities in Space," in *US-Soviet Security Cooperation*, Alexander L. George, Philip J. Farley, and Alexander Dallin, eds., (Oxford, U.K.: Oxford University Press, 1988), 370-431; Donald L. Hafner, "Averting a Brobdingnagian Skeet Shoot: Arms Control Measures for Anti-Satellite Weapons," *International Security 5*, no. 3 (Winter 1980-81): 41-60; Joseph S. Nye Jr. and James A Schear, eds., *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime*, (Lanham, Md.: University Press of America, 1987); Franklin A. Long, Donald L. Hafner, and Jeffrey Boutwell, eds., *Weapons in Space* (New York: W.W. Norton, 1986); Ashton B. Carter, "Satellites and Anti-satellites: The Limits of the Possible," *International Security* 10, no. 4 (Spring 1986): 46-98; H. Guyford Stever and Heinz R. Pagels, eds., "The High Technologies and Reducing the Risk of War," *Annals of the New York Academy of Sciences* 489 (New York: New York Academy of Sciences, 1986).
4. See Michael Nacht. "U.S. and China in Space: Cooperation, Competition or Both?" in *Antisatellite Weapons, Deterrence and Sino-American Space Relations*, (Washington: Stimson Center, September 2013), 101-112
5. For the diplomacy behind the Outer Space Treaty, see Raymond L. Garthoff, "Banning the Bomb in Outer Space," *International Security* 5: no. 3 (1980/81): 25-40. .
6. McGeorge Bundy, "To Cap the Volcano," *Foreign Affairs* 48: no. 1 (1969): 12.
7. Nikita S. Khrushchev, *Khrushchev Remembers* (Boston: Little, Brown, 1970), 493.
8. Ibid., 494.
9. Ibid., 500.
10. Bundy, "To Cap the Volcano," (1969): 10.
11. Ibid., 12
12. Matthew Kroenig, "Nuclear Superiority and the Balance of Resolve: Explaining Nuclear Crisis Outcomes," *International Organization* 67, no. 1 (2013): 166. For a contrary quantitative assessment, see Todd Sechser and Matthew Fuhrmann, "Crisis Bargaining and Nuclear Blackmail," International Organization 67, no. 1 (2013): 173-95.
13. Kenneth N. Waltz, "Nuclear Myths and Political Realities," *American Political Science Review* 84 no. 3 (1990): 738.
14. Lawrence Freedman, *The Evolution of Nuclear Strategy* (New York: St. Martin's Press, 1981), xviii.
15. See Michael Krepon and Sonya Schoenberger. "Annex: A Comparison of Nuclear and Anti-satellite Testing, 1945-2013," in *Antisatellite Weapons, Deterrence and Sino-American Space Relations*, (Washington: Stimson Center, September 2013), 131-137
16. See the Obama administration's *National Security Space Strategy, January 2011*, available at: http://www.defense.gov/home/features/2011/0111_nsss/docs/NationalSecuritySpaceStrategyUnclassifiedSummary_Jan2011.pdf

17. Michael Krepon, "How Not to Test in Space," *Space News*, Nov. 16, 2011.
18. The United States carried out three, and the Soviet Union carried out four or fewer. For details of Cold War ASAT tests, see Paul Stares, *Space and National Security* (Washington: Brookings Institution Press, 1987).
19. Brian Weeden, "2007 Chinese Anti-Satellite Test Fact Sheet." Superior, CO: Secure World Foundation, updated Nov. 23, 2010. http://swfound.org/media/9550/2007%20chinese%20asat%20test%20factsheet.pdf.
20. See James Lewis, "Reconsidering Deterrence for Space and Cyberspace" in *Anti-satellite Weapons, Deterrence and Sino-American Space Relations*, (Washington: Stimson Center, September 2013), 61-79
21. See Bruce W. MacDonald, "Deterrence and Crisis Stability in Space and Cyberspace," in Anti-satellite Weapons, Deterrence and Sino-American Space Relations, (Washington: Stimson Center, September 2013), 81-100
22. Kurt Gottfried and Richard Ned Lebow, "Anti-Satellite Weapons: Weighing the Risks," *Daedalus*, 114, no. 2 (Spring 1985): 148.
23. Michael Nacht, "U.S. and China in Space: Cooperation, Competition or Both?" in *Anti-satellite Weapons, Deterrence and Sino-American Space Relations*, (Washington: Stimson Center, September 2013), 101-112
24. *Report of the Commission to Assess United States National Security Space Management and Organization, Pursuant to Public Law 106-65* (Washington: Commission to Assess United States National Security Space Management and Organization, 2001) Executive Summary. xii http://www.dod.mil/pubs/space20010111.pdf
25. Ibid., X.
26. Bernard Brodie, "Some Notes on the Evolution of Air Doctrine," *World Politics* 7, no. 3 (1955): 359.
27. *Report of the Commission to Assess United States National Security Space Management and Organization, Pursuant to Public Law 106-65* (Washington: Commission to Assess United States National Security Space Management and Organization, 2001): 8. http://www.dod.mil/pubs/space20010111.pdf
28. This terminology has been borrowed from Steven Weber and Sidney Drell, "Attempts to Regulate Military Activities in Space," in Alexander L. George, Philip J. Farley, and Alexander Dallin, eds., *US-Soviet Security Cooperation: Achievements, Failures, Lessons* (New York: Oxford University Press, 1988): 373-431.
29. See Michael Howard, "Reassurance and Deterrence: Western Defense in the 1980s." *Foreign Affairs* 61, no. 2 (1982-3): 309-324.
30. See Brian Weeden. "U.S.-China Cooperation in Space: Constraints, Possibilities, and Options" in *Anti-satellite Weapons, Deterrence and Sino-American Space Relations*, (Washington: Stimson Center, September 2013), 113-130

The Absolute Weapon and the Ultimate High Ground: Why Nuclear Deterrence and Space Deterrence Are Strikingly Similar - Yet Profoundly Different

By Karl P. Mueller

In his introductory essay to this volume, Michael Krepon surveys and compares nuclear deterrence to the related and still rather nascent policy arena of space deterrence. This chapter takes another look at space deterrence, approaching the comparison from a slightly different direction by focusing on theory and strategic principles while giving short shrift to the history of the policy-making in question that his chapter presents in detail.[1]

The connections between space power and deterrence have been a matter of increasing interest in recent years as the United States has become more and more dependent on space systems to perform essential military functions, and as the rise of China has demonstrated that deterrence is central to national security policy in all ages, rather than being something that mostly mattered during the Cold War. As we think about these connections, it is natural to turn to nuclear deterrence in a search for useful analogies. The study of nuclear deterrence, embracing both theoretical and practical dimensions, has achieved the often elusive objective for a highly theoretical discipline of actually having been useful to policymakers.

Nuclear power is different from conventional power in important respects, and space power is different from terrestrial power. Does understanding nuclear deterrence, in particular, give us useful insights into deterrence in space? Or do nuclear and space deterrence have more in common with each other than they do with other varieties of deterrence? It would be nice if the answer were "yes" because decades of thinking very hard about nuclear deterrence has resulted in a well-developed body of theory about it,[2] although much of it has not been tested due to the absence of nuclear wars and the infrequency of deep nuclear crises. Even though we have seen no nuclear weapons fired in anger since 1945, deterrence is not mere guesswork: The absence of explosions does not indicate the absence of deterrence; it indicates the absence of deterrence failures.

This brief essay will argue, or at least assert, that it is important for anyone seeking to understand space deterrence to have a basic mastery of nuclear deterrence – indeed, anyone seriously interested in national security affairs at the level of relationships between major states ought to have a grasp of this now relatively neglected subject. There are noteworthy analogical nuggets to be found in such a comparison – some metaphorical, others more concrete. But in the end, nuclear deterrence and space deterrence differ in so many ways that the contrasts between them are far more pronounced, and more illuminating, than the characteristics that they have in common.

DETERRENCE

It is not only natural but essential to begin by establishing what deterrence is and how it works in general. The term is often bandied about with limited regard for conceptual precision, and, even among those who do concern themselves with clearly defining deterrence, there is less consensus about what it does and does not comprise than one might expect. Search the political science literature for explicit and implicit definitions of deterrence – if one has nothing better to do – and one will find disagreements about whether it is proper to apply the deterrence label to threats of denial as well as punishment, to promises as well as threats, to wars being averted by external conditions or self-restraint as well as deliberate signaling by an opponent, to the non-occurrence of wars that no one was very interested in starting in the first place, to preventing wars before a crisis occurs, and even (though mostly in works of several decades past) whether there can be such a thing as non-nuclear deterrence.

Usually a broad definition of deterrence is most useful for scholarship, and even more so for policymakers who are interested in results more than debates about taxonomy. For the present discussion, it will suffice to say that deterrence refers to trying to cause someone not to do something (such as starting a war) by changing their expectations about the consequences of their potential actions (and also to the outcome of such efforts if they are successful). Deterrence is a subset of coercion,[3] and can (and should) be differentiated from actions that reduce or eliminate the adversary's ability or opportunity to misbehave instead of deterring it from doing so; the latter is the domain of "brute" or "pure force," destruction or unconditional appeasement.[4]

This is not the place for an extensive primer on deterrence, so I will settle for making four important points about the subject. First, and most fundamentally, deterrence is something that occurs in the mind of the enemy. It is a function of the opponent's expectations, which in turn depend on their perceptions and beliefs; objective reality usually affects these, but when what is real diverges from what is perceived, it is the latter that matters. (In contrast, defense is what happens if deterrence fails, at which point objective reality takes over.) Thus, bluffs may deter but will not provide protection if they are called, while the opposite is true of defenses that the enemy does not know about. Similarly, escalation thresholds are what the actor responding to them thinks they are which may not align with the expectations of an adversary.[5]

> *if the enemy "has nothing to lose," even a very risky action may be preferable*

Second, deterrence is about the relative attractiveness or unattractiveness of alternative courses of action. States do not go to war because they expect to win, they do so because they expect to be better off if they attack than if they do not. If the expected value of the status quo is very low (if the enemy "has nothing to lose"), even a very risky action may be preferable (picture Japan in 1941), while an actor who is well contented with his current situation may find even the prospect of cheap and easy victories to hold little appeal. For the deterrence practitioner this means it is always important to consider how the alternatives will stack up against each other in the opponent's eyes, and to keep in mind that making the status quo look better can be just as useful for deterrence as making war look worse.[6]

This leads into the third point, which is that there are many ways to deter, since there are multiple approaches to making an opponent think that starting a war or escalating a conflict would be worse than not doing so. Prudent deterrers will look for opportunities to exploit across this range, and will be attentive to the risk that a threat or promise in one avenue will undermine deterrence efforts in another:[7]

- Punitive deterrence involves increasing the expected costs of one or more potential outcomes of the action to be deterred. Examples range from retaliatory nuclear attacks to inflicting a lot of casualties on the battlefield to threats of economic or diplomatic punishment – including by third parties. The most potent punitive threat will be ones that apply whether or not the opponents' action succeeds.
- Deterrence by denial works by making the desired outcome of an action, such as victory in a war, appear less likely and some less appealing outcome look more likely. Decreasing your apparent vulnerability to an attack is a good way to discourage it, but some threats are harder to foil than others, and relatively weak deterrers may have little ability to threaten defeat or even frustration against a more powerful opponent.

- Rewards and reassurance (positive deterrence if you prefer) seek to make aggression or escalation less attractive by making the status quo look more beneficial or less dangerous to the potential adversary. If the opponent expects that the result of restraint will simply be a war on less favorable terms later, there will be little incentive for restraint.
- Unconditional measures of various sorts can also contribute to the prospects for deterrence, though strictly speaking they are not coercion. Destroying a key enemy military capability before it is used can make a threat less dire; at the other end of the spectrum, settling an existing dispute may eliminate the principal motive that might otherwise lead to war.

Finally, when moving from the theoretical plane to making strategy for the real world, talking about deterrence in general is rarely very useful, instead it is essential to specify whom you want to deter from doing what (and under what conditions). Even for the same opponent, the best approach for deterring it from taking action A may not be ideal, or even effective, for deterring it from closely related action B. Conversely, a strategy that is well suited to deterring one target from a particular form of misbehavior may be a very poor choice for deterring someone else from doing the same thing.

NUCLEAR DETERRENCE

With this last point firmly in mind, it is worth taking a moment to be clear about what the term "nuclear deterrence" means, which is not quite as simple an issue as one might assume. In everyday conversation, nuclear deterrence usually refers to using nuclear threats or nuclear weapons (which is more or less the same thing most of the time) as a deterrent tool. Thus, we might argue about whether nuclear deterrence can be relied upon in a particular case not only to deter an opponent from employing nuclear weapons but also to deter any number of non-nuclear actions such as invading a neighbor using conventional military forces. However, for the purposes of comparing nuclear and space deterrence, it will be more useful if we instead scope our consideration of nuclear deterrence based on what is being deterred rather than what is being used to do it: that is, to think about how the use of nuclear weapons has been and can be deterred, whether by threats of nuclear response or other means entirely, including but not limited to conventional military action.

SPACE DETERRENCE

The reason for framing nuclear deterrence as deterrence of nuclear use rather than deterrence by nuclear threat is that when we talk about space deterrence we almost always have in mind deterring attacks against satellites and related space systems, not the use of space capabilities for deterrent purposes, which is a vast and multifaceted subject given the variety of functions that space systems perform.[8] However, this is still quite vague by the standards of the "deterring whom from doing what?" criterion.

There are many ways to attack or interfere with satellite operations, ranging from the literally inoffensive (such as deception measures against imaging) through various flavors of jamming, dazzling and other non-kinetic attacks with either temporary or lasting effects, up to outright attacks by projectiles, directed energy weapons or other means to damage or destroy satellites. (Alternatively, targeting the ground segments of space systems may be an easier and more attractive option, but this largely falls outside of what we usually have in mind when discussing space deterrence, since deterring such actions is essentially the same as dealing with threats to other terrestrial targets.) For the purposes of this discussion, we will focus on the high end of the scale, leaving aside low-grade interference with satellites or the services they provide; also omitted will be any serious consideration of cyberattacks directed against space-related systems, since deterring such actions involves a broad topic of deterrence analysis unto itself.[9] Thus, references to "space weapons" in the pages that follow can be read as synonymous with "anti-satellite (ASAT) weapons," always keeping in mind that among the ranks of potential ASATs are a variety of weapons and tools that are primarily intended for other purposes, from mid-course ballistic missile defenses to manned spacecraft.[10]

The issue of who might need deterring and under what circumstances often receives less attention than it merits. It is easy to list a wide variety of potential adversaries who might be interested in launching ASAT attacks against the United States or its allies if they had the capability to do so, but in practice there is a relatively limited set of opponents and scenarios that appear to be plausible foci for space deterrence concern rather than merely being imaginable.

It is worth noting that in virtually every conflict the United States is vulnerable to attack in many forms and many places that are not actually carried out, either because enemies lack the inclination to do so (before or after taking the likely consequences into account), because they lack the imagination to recognize the possibility, or because they have more attractive things to do with their capabilities. Although satellites are intrinsically vulnerable to attack in absolute terms, thanks to orbital mechanics and the limited potential for concealment in space, on the whole they tend to be relatively challenging targets for physical attack when compared with the relevant alternatives. The most economically valuable satellites, and many of the most militarily important ones, operate in high orbits that make them much more difficult to attack than their counterparts in low Earth orbit (LEO). Moreover, enemies interested in inflicting economic damage or psychological trauma on the United States will find many easier ways to do at least as much harm by striking terrestrial targets. This is likely to be less true for attacks seeking to cause military damage or disruption, but even there, striking at the ground segments of space systems, or interfering with their effective operation through terrestrial jamming or other means, will often be easier than attacking the satellites themselves in orbit.

Yet there are conditions under which attacking US satellites might indeed appear to be sound policy for an adversary, even though these are likely to be more limited than is often supposed. Three sets of circumstances loom especially large. The first is situations in which an ASAT attack, or a series of them, would offer a substantial military payoff in a situation of ongoing or imminent crisis or conflict. This would be most likely if attacking satellites were a way to exploit key vulnerabilities of US military power; how substantial the potential for that to be the case in the future will depend greatly on the ways in which the United States carries out the various elements of its military transformation plans over the coming generation, in addition to how well it deals with the challenges of satellite protection per se. Achieving such effects on a large scale would require considerable ASAT capabilities, and thus would likely be the purview of relatively major powers.[11]

Second, ASAT attacks promising more limited benefits might be attractive in cases where ASAT capabilities had already been built – perhaps only as a deterrent to US ASAT attacks – and a conflict or crisis subsequently broke out in which it appeared likely that the systems eventually would be destroyed or rendered ineffective: a “use it or lose it” situation. In a conflict in which the adversary faced the prospect of conquest or regime change being imposed by the United States, of course, every weapon would fall into the “use it or lose it” category, and high stakes (and possibly psychological desperation) could be expected to make deterrence particularly difficult.

Third, ASAT attacks could be appealing by offering a way to attack the United States or its allies (or to send a powerful coercive signal about one’s willingness to use force) while limiting escalation risks, making retaliation problematic or allowing the state launching them to maintain the moral high ground. Damaging or destroying satellites could cause considerable economic or perhaps military damage without killing many people – depending on the nature of the attack it is conceivable there would be no immediate loss of life – and without attacking the adversary's homeland. Among the possibilities, a high-altitude nuclear detonation could offer a way to employ nuclear weapons without causing mass destruction, in response to which the likelihood of US nuclear retaliation might appear to be quite low.

SIMILARITIES: THE POWER OF ROCKET SCIENCE

Why should we expect nuclear and space deterrence, and nuclear and space power more generally, to have a lot in common a quarter century after the end of the Cold War? [12] That the association seems intuitively natural, at least at first, would seem to have much to do with the technologies that underpin these policy realms.

> *Why should we expect nuclear and space deterrence to have a lot in common a quarter century after the end of the Cold War?*

Perhaps the most obvious nuclear-space parallel is that power and deterrence in both cases are conspicuously and intimately connected to space age (and information age) physics. This matters on at least two levels. One is that to participate usefully in discussions of either nuclear or space deterrence it is necessary to have a basic grasp of the science involved in the field, as well as an understanding of deterrence and of the larger strategic context. This does not mean that one has to be able to design an atomic bomb, a missile or a satellite to discuss them intelligently, or that having deep expertise in the science or engineering of either field necessarily will make one more astute about related policy issues than someone with more rudimentary knowledge of the subject – Albert Einstein was far from prescient about the realities of a nuclear-armed world. But just as knowing the difference between a bomber and a ballistic missile or why multiple independently targetable reentry vehicles (MIRVs) mattered was indispensable for thinking about nuclear deterrence in the Cold War, and understanding the differences between nuclear and chemical weapons is essential to discussing weapons of mass destruction intelligently today, wrestling with issues of space deterrence requires knowing something about orbits and gravity wells and the functions that satellites perform.

This isn't really a problem – or rather it shouldn't be. A bright undergraduate can learn enough about nuclear weapons and strategy in a few hours to opine intelligently about nuclear deterrence. Space is somewhat more complicated, but the intellectual entry costs are also far from prohibitive. [13] Yet military space power has become – indeed it has always been – primarily the preserve of a relatively small group of specialists, both within the US Air Force and other armed services and in the broader policy-making and policy-assessing world. A variety of factors contribute to this, some relate to the domain knowledge being fairly arcane, some are sociological and all are reinforced by the secrecy that surrounds many national security space activities and programs, particularly the most advanced and expensive ones. Something analogous is true of nuclear strategy and policy, particularly since the end of the Cold War when the use of nuclear weapons seemed to become a far more remote possibility and interest in nuclear arms control diminished accordingly – as did the attention devoted to the subject in staff and war colleges, civilian universities and most other places where issues of nuclear policy were once matters of mainstream concern and debate.[14]

In practice, the peripheralization and sometimes isolation of the communities of nuclear experts and space experts can have potentially serious consequences. It can narrow or stifle debate and innovation (although this is not inevitable – isolation can also create space for innovation by excluding people who would interfere with it) and may facilitate or perpetuate dysfunctional processes or policies. More dangerously, if nuclear or space strategy becomes a domain disconnected from the broader national security community, either inside or outside of government, it can leave the United States ill-prepared to deal with crises and other events involving these capabilities by making them less familiar to non-specialist military and civilian leaders. Coming to grips with the realities of space power and space deterrence, as with the corresponding nuclear issues, is not something to undertake once a crisis in which they loom large is already underway.

PROLIFERATION

Nuclear and military space capabilities both began as the exclusive domain of the superpowers, and subsequently have spread gradually to other countries. Originally the entry costs of nuclear weapons and space programs were astronomical. Beyond the United States and the Soviet Union, many of the largest and wealthiest major powers decided not to take on the expense and inconveniences associated with making the effort to join the nuclear club – and powers that did generally contented themselves with relatively small arsenals.

Over the past 50 years, the economic barriers to becoming a nuclear power have eroded to some degree. It is still no small matter to achieve entry into the nuclear club, but much of this difficulty is due to deliberate action to raise political and other obstacles to nuclear proliferation. As South Africa demonstrated in the 1980s, developing a basic atomic weapons capability has become something that virtually any sizable, sufficiently motivated state can achieve eventually. North Korea more recently drove this point home. That relatively little nuclear proliferation actually occurs reflects a dearth of countries that want the bomb more than a lack of countries' abilities to acquire it.

> *That relatively little nuclear proliferation actually occurs reflects a dearth of countries that want the bomb more than a lack of countries' abilities to acquire it.*

The story is not terribly different in space. Here we are not thinking so much about the growing roster of states that have become spacefaring by owning their own satellites as about the slower but significant spread of space launch, ballistic missile and other capabilities that could be used as the basis for operational antisatellite capabilities. [15] As with nuclear weapons, the entry costs are considerable, requiring the resources of a state rather than an eBay account and a credit card, but it is now a game in which states other than superpowers certainly can play.

> *States do not, as a rule, stumble into becoming nuclear powers.*

There is also a clear parallel between the proliferation of nuclear and space capabilities on the political side: No state has ever developed nuclear weapons or substantial military space assets just for their cachet, but considerations of prestige can figure into such decisions to an important degree, as illustrated by the Cold War space and arms races between the United States and the USSR.[16] This can matter to deterrence by, for example, leading governments to acquire or maintain destabilizing weapons for reasons other than their strategic utility, or contributing to provocative arms racing behavior.

These things being said, it is worth noting that there are important differences between joining the nuclear and the military spacefaring clubs. One is that civil and national security space tends to be very intertwined on multiple levels, so states can find the need to contemplate issues of space power and space deterrence thrust upon them as a result of going into space for reasons that have little to do with military power. In contrast, while civil nuclear programs and nuclear weapons programs can certainly be related to each other, states do not, as a rule, stumble into becoming nuclear powers,[17] though they may well achieve that status without having fully thought through all of its implications.

Another contrast is that, so far, nuclear weapons have always remained in the clear possession of a single state, or at most a few states under a dual-key arrangement where the weapon belongs to one country but is based in, and perhaps delivered by, a system belonging to a close ally. For many space systems against which the United States might want to deter attack, things are not so simple. Satellite constellation may be owned by international consortia or multinational corporations, for example, and there might be many users of a single system, changing frequently as transponder leases change or new contracts are let for space-based services. This makes deterrence more complicated, though greater complexity doesn't necessarily imply greater difficulty. For example, one argument in favor of US military use of non-US satellites for functions like communications is that an enemy might be reluctant to attack third-party satellites with a broad customer base in a situation where it would be willing to attack ones whose loss would hurt only the United States.

CRISIS STABILITY

Of central importance to deterrence, more or less by definition, are issues of crisis stability. [17] When prospective combatants have strong incentives to strike first in a confrontation, because they would be much better off by doing so than if the opponent landed the first blow, deterrence becomes much more difficult than if there is little incentive for preemption. The same is true for decisions about whether to take escalatory action in a conflict already underway. Here, again, there are noteworthy parallels between nuclear and space deterrence. (There are important differences as well, and we will return to the subject of crisis stability in the next section.)

The two most important of these similarities both derive from the tendency for nuclear and ASAT attacks to be difficult to defend against. Defending against ASAT attacks tends to be hard because of physics and the geography of orbital space: Satellites are difficult, even often impossible, to conceal and difficult or costly to maneuver out of harm's way. Defending against nuclear strikes can also be very hard, particularly when the weapons are delivered by ballistic missiles, but the fundamental problem with trying to intercept incoming nuclear warheads is that even defenses with a high success rate may be of little strategic value because a very small number of "leakers" can be sufficient to cause vast destruction. If an attacker has high confidence that an attack of either type will be at least operationally successful because defenses are not effective, deterrence efforts will need to focus on punishment and reward strategies because deterrence by denial will have little to offer. This is a problem that extends beyond the confines of crisis stability, but it can be especially acute in a crisis by creating powerful incentives for a first strike if war appears inevitable, or even merely likely. Moreover, when the stakes are high, making punitive threats (or reward offers) that are powerful enough to deter, absent being able to threaten an attacker with actual defeat, can be a very difficult strategic mountain to climb.

The second issue is closely related. Under conditions of real or perceived first-strike advantage, and with weapons for which tactical warning from detection to attack may be measured in minutes (or even less for some directed energy attacks or for attacks by prepositioned "space mines"), decision-making timelines are likely to be very compressed. [18] This can cause or contribute to a witch's brew of pathological effects, limiting opportunities for communication and signaling between adversaries or mediation by third parties, constraining the collection and analysis of information and consideration of alternative options, even causing panic and other psychological problems for decision makers under intense pressure.[19]

> *Decision-making timelines are likely to be very compressed. This can cause or contribute to a witch's brew of pathological effects*

It is important to qualify this discussion, however. While defense against nuclear and ASAT attacks tends to be difficult, the verb is intentionally tentative; the extent to which the tendency manifests itself in practice will depend on the weapons and defenses that the nations involved choose to deploy. Weapons that are vulnerable to attack will threaten crisis stability much more than ones that have a reasonable prospect of surviving an enemy first strike; weapons that are particularly or only vulnerable to surprise attack are likely to be especially destabilizing. Thus systems such as unhardened, MIRVed, land-based ballistic missiles or space-based ASAT laser weapons are crisis stability nightmares, combining offensive usefulness with great potential vulnerability that creates "use-it-or-lose-it" incentives for decision makers not to risk allowing a powerful adversary to strike first.

ENVIRONMENTAL EFFECTS

As a coda to close out this enumeration of parallels between the arenas of nuclear and space deterrence, it is also worth noting briefly the similarities among some of the potential environmental consequences of nuclear and space warfare. The physics of nuclear fallout and of orbital debris due to kinetic-energy ASAT attacks are entirely different, but from a policy perspective they have much in common. Both are potentially serious and, on a large enough scale, catastrophic contamination threats that originate as collateral effects of particular attack methodologies – or that can be generated deliberately as a means of inflicting additional harm on an enemy. Because their effects are essentially indiscriminate, affecting geographically vulnerable bystanders without regard for national borders, they magnify the extent to which deterring nuclear or space combat is a matter of concern to non-belligerents, and cast a long shadow over issues of weapon investment and testing.

> *There is more than a passing resemblance between "nuclear winter" fears and the threat of nuclear ASAT use making large swaths of low-earth-orbital space uninhabitable*

At the extreme end of the scale, it is not unreasonable also to suggest that there is more than a passing resemblance between "nuclear winter" fears during the Cold War and the threat of nuclear ASAT use making large swaths of low-earth-orbital space uninhabitable for unhardened satellites due to the excitation of the Van Allen radiation belts that could persist for months or years. The latter effect would be far less cataclysmic, and more easily generated, than the former, but both would have global and relatively long-term consequences that bear heavily on the deterrence calculus for prospective attacks that might trigger such results.

DIFFERENCES: AN ABUNDANCE OF UNIQUENESS

These and other parallels between nuclear and space deterrence, and between nuclear and space power more generally, are significant and can be illuminating; failing to be aware of them would certainly be unfortunate. On the other hand, not recognizing the differences between the two subjects can be actively perilous, leading to misconceptions that invite strategic surprise and major policy missteps.

THEORY

In spite of the similarities identified above, nuclear deterrence and space deterrence aren't really parallel concepts. Indeed, it is not entirely clear that space deterrence is a very useful construct – we do not speak of air or naval deterrence as distinct categories, after all, because of the degree to which conventional warfare in different domains is usually intermingled. Military space activities, too, are intimately connected to operations and capabilities in the other domains. This is not to say that deterring attacks against satellites and other space-related targets is not a matter of importance, only that it is a policy problem that may be less separate from other deterrence challenges than is often assumed.

> *It does not follow that because space and nuclear power each work differently from conventional military power they must then resemble each other.*

Yet space really is different – the unique operating environment and, above all, the physics of orbital mechanics, create an operational and strategic world in which conventional wisdom often does not apply. The same can be said of nuclear strategy and deterrence, but it does not follow that because space and nuclear power each work differently from conventional military power they must then resemble each other. For example, during the Cold War it was often noted that nuclear weapons could turn familiar notions of offense and defense upside down: Strategically, threatening to attack an enemy's nuclear arsenal was offensive, but threatening to annihilate enemy cities was fundamentally defensive, albeit unsavory. Similarly strategic defenses threatened to undermine deterrence if they protected a superpower's cities, but not if they only defended its retaliatory nuclear capabilities. In space warfare, too, the meanings of offense and defense familiar from settings such as air warfare become inverted, though in a different way. In this realm, attacking enemy satellites even over one's own territory is reckoned to be offensive counter-space activity, while protecting one's own satellites as they overfly the enemy is defensive.

More central to space deterrence, it is worth considering a very basic question: Is attacking another state's satellites a step up the escalation ladder from attacking terrestrial forces, or a step down?[20] Discussions about how to deter antisatellite attacks often take for granted the idea that, if possible, we should try to contain the use of force within the atmosphere, frequently proposing that the US government declare redlines to emphasize that ASAT attacks will be treated as extremely grave offenses, inviting severe responses. One could look alternatively at warfare in space and conclude that with a low expected body count, it should be considered milder than terrestrial conflict. Chinese writings that touch on this subject generally adopt a perspective that sees attacks on enemy space systems as unexceptional. The point here is not that one attitude is the correct one, but that the answer is sufficiently ambiguous that there is considerable potential for deterrence to be complicated by a lack of common thinking between the parties concerned. Such misunderstandings are by no means impossible when it comes to nuclear deterrence, but they are more likely to be limited in scope given the power of nuclear threats to concentrate the mind.

DESTRUCTIVENESS

The most fundamental difference between nuclear and space weapons and, in turn, between nuclear and space deterrence, is one of the simplest: Nuclear weapons are extremely destructive. This can seem like a truism, certainly everyone knows that it is true, yet it is surprisingly easy to discount – perhaps the clearest illustration is the frequency with which we refer to "weapons of mass destruction" or even "CBRNE" weapons – lumping nuclear weapons together with vastly less destructive ones.[21]

The reason we speak of "the absolute weapon" and "the nuclear revolution" is that the difference in destructive power between conventional and nuclear explosives makes the latter qualitatively different from the former, with relatively modest arsenals being capable of inflicting truly catastrophic harm on an enemy in relatively short order. [22] Crucially, in many cases, even a state that is losing a war would be able to threaten to inflict such harm against a successful adversary. It is this result of the coupling of nuclear weapons with airpower and missiles that makes nuclear strategy and nuclear deterrence distinctive. Among states with reasonably robust nuclear arsenals, all that is really required is a reasonable expectation that one's retaliatory capabilities will not be eliminated or disabled by an enemy's first strike. There are very powerful incentives to avoid war, or to avoid very much escalation if a limited conflict does break out. This does not mean that deterrence will never fail or that escalation will always be controlled, but the deck should be relatively well stacked in favor of strategic stability and successful deterrence.

For space weapons and space deterrence the situation is very different. There may still be strong reasons for mutual restraint, but the prospect of catastrophic human costs if a war breaks out in space or if a terrestrial conflict spreads there is not likely to be one of them. Instead, one of the reasons that attacks on space systems might be attractive is their potential to cause the enemy great military or economic harm without generating a large body count. Indeed, some early advocates of space weapons development argued for the merits of shifting military competition and conflict into space at least partly on such humanitarian grounds. (Even nuclear weapons might be employed in space without killing many people, possibly none at all.)[23]

Consequently, there is little reason for leaders to quail at the prospect of using weapons in space during a conflict as they do with respect to employing nuclear weapons. To be sure, attacking an enemy in space would likely appear to be a dramatic action of much import, particularly because it would be largely unprecedented. However, once the decision to go to war, or even to risk war, against a powerful enemy has been taken, the significance of also employing space weapons is likely to be figuratively, as well as literally, marginal. The problem of convincing an enemy that is willing to fight the United States within the confines of the atmosphere that it should not also be willing to extend that conflict to space, if doing so appears militarily advantageous, is a daunting deterrent challenge.

> *The size and sophistication of a nuclear arsenal matters less for deterrence than the apparent willingness to use it.*

Another consequence of the destructive power of nuclear weapons is that once a state possesses even a fairly small number of deliverable nuclear weapons, the size and sophistication of its arsenal is likely to matter less for deterrence than the apparent willingness to use it . Under most circumstances, credibility is less of an issue for anti-satellite weapons – threats to employ them are more likely to be believed because the intrinsic costs of doing so will be lower – but their actual capabilities will tend to be in doubt until they are demonstrated. Therefore, the incentives to offer such demonstrations prior to a conflict may be great, either for deterrent or compellent leverage.

STRATEGIC STABILITY

We have already mentioned the issue of stability and first-strike advantage in nuclear and space strategy when discussing nuclear-space parallels, noting that both nuclear and space weapons tend to be hard to defend against. However, this similarity at the tactical and operational level breaks down on a broader scale. Viewed strategically, nuclear weapons tend strongly to favor the defense because it is so difficult to disarm a competent nuclear-armed opponent decisively through aggressive action, given that even a small number of surviving weapons can matter so much. In space, on the other hand, offense dominance scales up: a power that strikes aggressively should be, in theory, able to get the upper hand, or at least get the greatest possible use out of whatever offensive counter-space capabilities it has invested in.

One of the reasons for this difference is that space weapons, and military space capabilities more generally, derive their significance from the roles that they play and the impact that they have in terrestrial warfare.[24] One might still wage a space war in isolation, with no accompanying hostilities occurring on the planet below, but even in such a case losses of space capabilities, even the control of space itself, would matter because of how advantages gained in space subsequently might be translated into military, coercive or other benefits in the terrestrial arena. Nuclear weapons also can be closely coupled to terrestrial warfare but, at the end of the day, they tend to trump conventional uses of force.

Once again we need to recognize that offense or defense dominance is ultimately shaped by the weapons that states build and the doctrines they embrace. It is possible, by accident or design, to develop force postures that enhance or weaken stability even when the basic attributes of key military technologies lean in another direction – this is not a simple matter of technological determinism. That being said, however, the tendency for nuclear weapons to make conquest and aggression more difficult rather than easier is extremely powerful, although one reason that nuclear deterrence tends to be robust is that nuclear deterrence failures have such potential to be horrific, which is the fundamental mechanism underpinning mutual assured destruction. Space warfare has no analogue for such secure second strike capability that could be similarly stabilizing, in spite of potential options to threaten a spacefaring state with very great harm by attacking its highly valued space assets.

CONCLUSION

As this essay has sought to sketch out, the parallels between nuclear and space deterrence are thought provoking and potentially illuminating. However, each of these domains involves key characteristics that are unique to it, so understanding one does not imply or constitute mastery of the other. The sense that there ought to be a close coupling between the two subjects may be due in part to the fact that each is exceptional. Bernard Brodie bestowed the label "the absolute weapon" on nuclear arms, establishing a tradition that was carried on by generations of nuclear scholars.[25] These are profoundly unconventional weapons because of their immense and unrivaled destructive power, which fundamentally shapes deterrence involving them in many ways even though the basic principles of deterrence still apply.

Space has its own superlative: It is "the ultimate high ground."[26] But this is a metaphor that must be handled with care. Space is not merely a higher-altitude version of air, it is a different operational environment, governed by a different set of physical laws. Orbital mechanics instead of aerodynamics make LEO space territorially indivisible; lack of traditional terrain or terrestrial weather create a unique landscape where it is difficult to hide; and time and distance operate on different scales than on the ground or in the air. This makes space ideal for performing some military functions, almost all of them involving the collection or transmission of information, and very ill-suited for others that can usually be far better performed by terrestrial or aerial systems that are not hundreds or thousands of miles away from their targets. [27] All of these considerations contribute to making space deterrence something different from nuclear or some other form of deterrence transplanted to a domain that is colder, darker and less familiar.

> *Understanding one domain does not imply or constitute mastery of the other.*

Because of the increasing centrality of nuclear, space and cyber issues to national security concerns in the 21st century, each of these deterrence domains (which we might respectively tag as "stronger, higher, faster" to borrow and reshuffle a familiar slogan) stands to be more and more important to deterrence problems in coming years. Each involves distinctive dynamics and accordingly needs to be addressed on its own terms. But in doing so, it is essential not to treat any of them in isolation from the others or from the broader field of deterrence, lest their interconnections, both in theory and in practice, be overlooked.

1. This essay reflects the views of the author, not those of any of his employers or the United States government.
2. See Karl P. Mueller, "Strategic Airpower and Nuclear Strategy: New Theory for a Not-Quite-So-New Apocalypse," in *The Paths of Heaven: The Evolution of Airpower Theory*, ed. Phillip S. Meilinger (Maxwell AFB, Ala.: Air University Press, 1997), 279-320.
3. As explained by Thomas Schelling in *Arms and Influence* (New Haven, Conn.: Yale University Press, 1966), coercion comprises deterrence and compellence, which resemble each other in most respects but differ in the nature of the coercive demand, with deterrence seeking to prevent a change of behavior and compellence seeking to cause one.
4. Ibid.; Glenn H. Snyder, *Deterrence and Defense* (Princeton, N.J.: Princeton University Press, 1961). Coercion can also be distinguished from persuasion, which seeks to alter the target's preferences or desires rather than merely to alter its calculations about how best to serve its existing interests.
5. Forrest E. Morgan et al., *Dangerous Thresholds: Managing Escalation in the 21st Century* (Santa Monica, Calif.: RAND Corp., 2008), 7-46.

6. Referring to this as "positive deterrence" (Thomas W. Milburn, "What Constitutes Effective Deterrence?" *Journal of Conflict Resolution* 3, no. 2 (1959): 138-145) unfortunately never has caught on, but whether one accepts the use of the "deterrence" label for the category, such positive sanctions of reward and reassurance, or the lack of them, are central to explaining many a deterrence success or failure. For a relatively rare examination of the differences between using threats and promises, see David A. Baldwin, "The Power of Positive Sanctions," *World Politics* 24, no. 1 (October 1971): 19-38.
7. For more discussion of the whole subject in a small package, see Karl P. Mueller, "The Essence of Coercive Air Power: A Primer for Military Strategists," *Royal Air Force Air Power Review*, 4, no. 3 (Autumn 2001): 45-56, http://www.airpowerstudies.co.uk/sitebuildercontent/sitebuilderfiles/aprvol4no3.pdf.
8. For a more extensive discussion of the subject, see in addition to other essays in this volume Forrest E. Morgan, *Deterrence and First-Strike Stability in Space* (Santa Monica, Calif.: RAND Corp., 2010).
9. See Martin C. Libicki, *Cyberdeterrence and Cyberwar* (Santa Monica, Calif.: RAND Corp., 2009).
10. Karl P. Mueller, "Totem and Taboo: Depolarizing the Space Weaponization Debate," *Astropolitics* 1, no. 1 (Summer 2003): 4-28.
11. This picture might look significantly different when considering the possibility of ASAT attacks using nuclear weapons. This would open the door to the use of one or a few weapons having disproportionately widespread effects, and the technological demands of adapting nuclear weapons and long-range ballistic missiles to the anti-satellite role are relatively small once one possesses and operates the systems for other purposes. However, it is worth keeping in mind that the incentives not to use nuclear weapons are quite powerful, even under fairly extreme circumstances. This does not mean that deterrence would necessarily succeed, but merely that the theoretical potential for nuclear ASAT use is likely to be quite a bit greater than the reality.
12. During the height of the US-Soviet military confrontation, the interconnections between nuclear weapons and national security space capabilities were so intense that it was not uncommon to see the latter almost entirely through the lens of the former, as in David E. Lupton, *On Space Warfare: A Space Power Doctrine* (Maxwell AFB, Ala.: Air University Press, June 1988).
13. See, for example, Barry D. Watts, *The Military Use of Space: A Diagnostic Assessment* (Washington: Center for Strategic and Budgetary Assessments, 2001).
14. The onetime popularization of knowledge about and interest in nuclear weapons policy was by no means just an inevitable result of nuclear tensions and arms races. Rather, it owed much to deliberate efforts to broaden debates on the subject beyond the ranks of governmental and technical specialists. See, for example, Ground Zero [Roger C. Molander], *Nuclear War: What's in it for You?* (New York: Pocket Books, 1982).
15. As noted above, there are also other means of interfering with space activities that pose smaller resource demands, including jamming, cybertattacks and old-fashioned kinetic attacks against ground elements of space systems.
16. The preeminent examination of motives for nuclear proliferation is Scott D. Sagan, "Why Do States Build Nuclear Weapons? Three Models in Search of a Bomb," *International Security* 21, no. 3 (Winter 1996/97): 54-86.
17. This is not to suggest that crises always precede wars, or that even when they do, they always present an opportunity for deterrence to succeed in the breach. Sometimes states simply decide that the deterrence calculus favors going to war and don't bother with an 11th-hour showdown, or wish to avoid tipping their hand in order to execute a surprise attack.
18. It is easy to forget that because space is very large, many types of ASAT attacks (or hypothetical space-to-earth attacks) would not happen instantaneously, due to interceptor flight times or the limitations of orbital mechanics. However, unambiguous warning of imminent attacks might be very late in coming, and in some cases recognizing attacks even after the fact could be problematic.

19. Irving L. Janis and Leon Mann, *Decision Making* (New York: Free Press, 1977); Robert Jervis, Richard Ned Lebow and Janice Gross Stein, eds., *Psychology and Deterrence* (Baltimore: Johns Hopkins University Press, 1985).
20. I have argued elsewhere (Morgan et al., *Dangerous Thresholds*) that the antediluvian metaphor of a ladder of escalation is best avoided for a host of reasons, not least being that one cannot accidentally fall up a ladder. But for the moment we will carry on with Herman Kahn's questionable term.
21. CBRNE stand for chemical, biological, radiological, nuclear and high-yield explosive. On the other hand, it is true that the "nuclear weapons" category is itself a broad one, comprising both fission and thermonuclear weapons that differ in explosive power by several orders of magnitude – not altogether different in degree from the divide between modern conventional munitions and atomic bombs.
22. The sheer magnitude of the damage expected from a nuclear war was foreshadowed by interwar expectation about the horrors that might be expected from a second world war. See, for example, Uri Bialer, *In the Shadow of the Bomber* (London: Royal Historical Society, 1980) and George H. Quester, *Deterrence Before Hiroshima* (New York: Transaction Publishers, 1986).
23. People concerned about anticipating potential threats to US security in space sometimes raise the specter of al Qaida or some other extremist group gaining possession of a nuclear-armed ballistic missile and firing it into space in order to damage American satellites. Setting aside the aspects of such a scenario that make it far-fetched, were terrorists actually to acquire such a weapon and insist on using it, it is hard to think of a more benign place to have them detonate a nuclear warhead.
24. Robert Preston et al., *Space Weapons, Earth Wars* (Santa Monica, Calif.: RAND Corp., 2002).
25. Bernard Brodie, ed., *The Absolute Weapon: Atomic Power and World Order* (San Diego: Harcourt, 1946); Bernard Brodie, Strategy in the Missile Age (Princeton, N.J.: Princeton University Press, 1959).
26. For example, Benjamin S. Lambeth, *Mastering the Ultimate High Ground: Next Steps in the Military Uses of Space* (Santa Monica, Calif.: RAND Corp., 2003).
27. Often implicit in the "ultimate high ground" metaphor is an assumption that higher is better, but of course this is not true of traditional high ground. High mountain peaks are too far removed from things of military importance, and are too inaccessible, to be of much practical military interest – as the Siachen Glacier vividly illustrates. Similarly, for most purposes, military aircraft are not optimized to operate at very high altitudes.

Reconsidering Deterrence for Space and Cyberspace

By James A. Lewis

The ability to deter attacks against networks or satellites is so limited that we can reasonably ask whether deterrence still makes sense as an organizing principle for strategy. Concepts of deterrence do not transpose well in a changed international environment against new classes of opponents with significantly different degrees of tolerance for risk, and that employ different weapons technologies that are less destructive and less attributable than was the case for Cold War deterrence built around nuclear weapons.

Deterrence, in its classic form, is the possession of sufficient military power to credibly threaten to use force if vital interests are endangered, thus dissuading an opponent from taking action. The paradox for deterrence today is that while the United States has the most advanced cyber and space forces in the world, they neither deter our opponents generally nor deter hostile acts specifically directed against US cyber and space assets. Threats by the United States to use cyber or anti-satellite (ASAT) attacks will not deter because these attacks cause only limited damage and do not put opponents sufficiently at risk. Threats by the United States to use military force to defend cyber or space assets will also fail to deter because in peacetime, these threats are not credible and in wartime, opponents are likely to judge that the benefits of an attack on cyber or space assets will outweigh the costs.

> *A pattern is emerging that nondestructive or reversible “attacks” cannot be deterred in peacetime.*

Deterrence still works as it was designed to work in the 1950s, stopping opponents from undertaking massive conventional wars or nuclear strikes, but it is largely irrelevant to the amorphous and indirect conflicts the United States faces today. While nuclear deterrence achieved success at a strategic level, it did not deter Soviet espionage, the use of proxies, or adventures at the strategic periphery when the Soviets perceived that the United States was weakened by failure in Southeast Asia.

Efforts to transpose deterrence to the space and cyber domains will be similarly unsuccessful. Deterrence has not prevented cyber espionage efforts by many countries, foremost among them China. Nor is cybercrime deterred. Deterrence has not prevented the jamming of communications by Iran and others. China, in at least one instance, has illuminated a US military satellite with a laser.[1] Russia has used coercive cyber techniques in two instances, against Estonia and Georgia. Moscow likely was deterred from direct military action in the first instance by Estonia's membership in NATO and because of the potential for damaging consequences in other areas such as trade or finance, but the Kremlin was not deterred from encouraging "patriotic hackers" to launch denial of service attacks against Estonian government websites and financial institutions.[2] While these denial-of-service attacks were only minimally disruptive, they created anxiety in Estonia over Russian intentions. A pattern is emerging that nondestructive or reversible "attacks" – incidents that do not involve death or destruction – cannot be deterred in peacetime.

> *The chief purpose of US military strategy now must be to rely on war-fighting capabilities rather than deterrence.*

Any reconsideration of the utility of deterrence must reassess Bernard Brodie's famous statement that, "Thus far the chief purpose of our military establishment has been to win wars. From now on its chief purpose must be to avert them. It can have almost no other useful purpose."[3] The mere existence of a strategic nuclear force was enough to deter major conventional conflict between the United States and Soviet Union. This is no longer the case. Today, in peacetime, opponents will test the thresholds for provocation. In war, opponents will assume that attacking US cyber assets is worth the cost. And unlike global nuclear war, limited, localized conflicts are winnable by one side or the other without incurring catastrophe. The chief purpose of US military strategy now must be to rely on war-fighting capabilities rather than deterrence. US military forces must be able to win battles and to fight through unavoidable attacks, rather than expecting to prevent them.

A CHANGED SECURITY ENVIRONMENT FOR DETERRENCE

Deterrence rests on a series of assumptions about how potential opponents recognize, interpret and react to threats of retaliation. Successful deterrence assumes that opponents will assess the threat of damaging consequences correctly if they undertake certain courses of action and that this will lead them to reject those actions as too risky or too expensive. Nuclear deterrence rested on a framework of political understandings between the two "peer" superpowers regarding strategic intent, military capabilities, diplomatic engagement at the most senior levels on military and security issues, and thresholds or redlines to constrain and manage conflict.

Common understandings allow for credible threats to be made with lower risk of misinterpretation. Signaling – tacit communications between adversaries – can manage and reduce the chance of misinterpretation, but signals require tacit understandings on "redlines" and thresholds, implicit or explicit understandings among potential opponents, and public statements about intentions. The political conditions for effective deterrence – an ability to influence an opponent's planning by making clear that certain actions carry unacceptable risk – required a process of direct and indirect engagement where opposing leaders explicitly discussed how risk should be calculated and how the balance of deterrent forces should be assessed. None of these political conditions exist for space or cybersecurity.

Deterrence, in its High Church nuclear application, actually may not have worked as we think it did.[4] The United States had nuclear weapons and threatened to use them if there was, in President Dwight D. Eisenhower's, words, "trustworthy evidence of a general attack against the West."[5] Eisenhower hoped that nuclear deterrence would obviate the need for more expensive conventional forces. Later administrations moved away from this position to experiment with various response options and different mixes of conventional and strategic forces. Creating a political and deterrent role for nuclear weapons required a long and tense set of interchanges between Moscow and Washington before they produced more stability than risk. A complex and arcane hierarchy of weapons, signals and strategies was assembled on the American side, but despite a high degree of openness, the intent of this deterrent hierarchy was not always fully understood by the Kremlin.

The political framework for Cold War deterrence took years to develop. It no longer exists, and has not been duplicated in Washington's relations with potential opponents. The United States no longer faces a single opponent, or even a single class of opponents. There has been a diffusion of potential opponents, from a single adversary with whom Washington had both processes and understandings, and who would at times mirror US actions, to a near-peer opponent in China, two confrontational states, Iran and North Korea, in tense regions, as well as non-state actors, with different vulnerabilities, strategies and attitudes towards risk.[6] Some of these new opponents lack the experience, institutions and skill to calculate the risk of certain actions; a few may misinterpret deterrent threats while others may not feel threatened at all.

To the extent that these understandings exist for cyberattack and ASAT warfare, they are drawn from existing international practice and agreement on the use of force and the right of self-defense.

These new opponents are rational in the sense that they calculate risk and benefits of actions against the United States, but their calculations are based on different assumptions and preferences. All but Russia lack the experience of the Cold War to guide their interpretation of American actions. Some overestimate their own strength. Others hold religious beliefs that may devalue deterrent threats. Some may be willing to accept higher levels of damage. Given preconceived ideas about the intent of US policy, the lack of a shared political framework to interpret actions and lack of experience, deterrent threats could easily be misinterpreted as aggression or ignored.

Similar factors shape the ability to deter non-state actors. Additionally, non-state actors have no cities or population to threaten or hold hostage, and their tolerance for risk is likely to be much greater than most nation-states. These individuals have already accepted a high degree of risk in pursuit of their aims and they believe their followers are already under attack. They may accept death as a necessary sacrifice. A threat intended to deter will at best only shape the planning of jihadis and other insurgents. Some non-state opponents may even welcome retaliation, expecting that the resultant collateral damage would justify and expand support for their cause.

From an opponent perspective, an overt, kinetic attack on an American satellite during peacetime would be considered very risky in that the opponent could reasonably fear the American response. Similarly, a destructive cyberattack against the United States carries a high degree of risk. A covert, non-destructive attack does not carry the same degree of risk. Key factors in opponent decision making will involve a calculation of how likely the attack is to be attributed to them and how beneficial the result of the attack will be in serving their purposes, bearing in mind that these purposes may be as diverse as testing avenues for asymmetric attack to prepare for conflict with the United States, making a statement of defiance or gaining espionage advantage.

DETERRENCE AND CHINA

In order to deter China from using ASAT weapons, China's leaders would have to calculate that an ASAT attack would lead to an escalation of conflict or to damaging retaliation. In peacetime, Beijing would probably calculate that an ASAT attack might risk being seen as a casus belli. If so, it is unlikely that China's kinetic or directed energy weapons would be used outside of conflict. If, however, Washington and Beijing are already engaged in an armed clash, the threat of the use of force in space is somewhat moot. Washington could, for example, threaten to escalate the conflict by warning that an attack on a satellite will result in the destruction of China's space launch complex. Beijing may nonetheless calculate that at this stage of its military modernization, interfering with US satellites is worth any retaliatory interference with their own satellites, and that the risk of escalation in other domains is either low or acceptable.

> *Chinese military leaders may underestimate risk and overestimate the utility of asymmetric attacks.*

There is some evidence that Chinese military leaders may underestimate risk and overestimate the utility of asymmetric attacks. China has little experience with the arms control negotiations that underpinned nuclear deterrence, has a different conceptual framework for conflict and international relations, and lacks the experience of the Cold War for interpreting American actions and signals. Chinese military concepts on "deterrence" differ significantly from US concepts, meshing Schelling's ideas of deterrence and compellence in ways that encourage use and increase the risk of miscalculation.[7] Deterring Chinese ASAT attacks during armed conflict would require threatening something other than China's own satellites, since the People's Liberation Army (PLA) is not yet so dependent on space assets that the satellites' loss would constrain their operations as much as the loss of American satellites would hurt US forces. In this situation, Chinese leaders may see an exchange of satellite attacks as working to their benefit. Only a credible threat to retaliate against a terrestrial target would change China's calculus, but such threats bring the risk of escalation of conflict that would need to be weighed carefully.

Responding to an attack on a military target in space or a military cyber network with an attack on the Chinese homeland would likely be seen by China as escalatory. Additionally, nationalist sentiment among the citizens of potential opponents like China or Iran suggests the most likely effect of US escalation unless it was sustained and broadly destructive, would be to reinforce support for the regime and for a continuation of the conflict.

Belief shapes perception. The Kremlin believed that the United States was inherently aggressive and sought the destruction of the Soviet Union. Soviet political and military leaders debated whether the US investment in weapons was to retain a credible deterrent or to attain first strike capabilities. Paranoia also colors how authoritarian regimes that lack domestic legitimacy view the United States. Cultural and linguistic differences also contribute to misinterpretation of deterrent messages.

CREDIBLE THREATS

The ability to make a credible threat is the core of deterrence. An opponent calculates the benefits of an action and compares these to the potential cost and the likelihood that such costs will actually be inflicted. The credibility of a deterrent threat is shaped by opponent perceptions and by their tolerance for risk. A threat that poses unacceptable risk will deter. A number of factors shape this calculation of unacceptable risk. For state opponents, a deterrent threat must entail existential risk or a compelling and unavoidable threat to the state's core interests, such as its territorial integrity or political independence. A central flaw in deterrence theory today is that, in the wake of wars in Afghanistan and Iraq, few opponents find it credible that the United States will use expeditionary forces in retaliation to provocations.

Unlike other military technologies, nuclear weapons pose an existential threat. If used, damage and casualties would be massive. In contrast, neither cyberattacks nor ASAT attacks pose the same level of destructiveness; they certainly are not existential threats. If there was some way credibly to threaten the use of nuclear weapons after a cyberattack, deterrence might be possible. However, a nuclear threat in response to these attacks would not be proportional and the threat to use nuclear weapons is likely to be discounted by opponents. There are powerful norms that constrain the use of these weapons, and therefore, a threat to use nuclear weapons in response to cyberattacks would be dramatic but not credible. Calls for a nuclear response to cyberattacks would be dismissed as frivolous. Threats to use military force to retaliate against an act that would not be considered as justifying the use of force in self-defense under international law or practice will likely be dismissed by opponents as bluster.

To be credible, a deterrent threat also would have to impose an "unacceptable loss" on the opponent. Former Secretary of Defense Robert McNamara calculated that the "unacceptable loss" required for the nuclear deterrence included half of Soviet industrial capacity, at least two-thirds of their military forces and perhaps a quarter of their civilian population.[8] These damage estimates would be ridiculously disproportional to the loss of a satellite or the disruption of a computer network. It would require bizarre calculations (by both the United States and opponents) to determine the thresholds for losses of satellites or computer networks that would trigger massive retaliation like that envisioned by McNamara during the throes of the Cold War.

An extensive discussion that began in the 1950s sought to gauge the utility of different deterrent scenarios and exchange ratios ranging from massive relation to flexible response, or between counter-value and counter-force strikes. These calculations were complex and their results easily misinterpreted. Contemporary strategic calculations could only increase in the event of “cross-domain” deterrence. If, for example, Washington responds to an attack on a satellite by attacking a space launch facility, this would be seen as disproportional and as escalatory.

> *The ability to deter attacks against networks or satellites is so limited that we can reasonably ask whether deterrence still makes sense as an organizing principle for strategy.*

Overly broad definitions of “vital interests” are both unhelpful and inaccurate. A precise definition would identify vital interests as the territorial integrity and political independence of the nation. Determining what causes serious harm to the national interest is a political decision, but there are identifiable upper and lower bounds. Drawing on the UN Charter, actions that threaten the territorial integrity or political independence of a nation would certainly count as a threat to vital national interests.[9] Disruption of economic relations or of communications (subject to Pictet’s tests of scope, duration and intensity)[10] could qualify as serious harm to the national interest. A simple test for vital interests would be to determine if a nation’s political leadership (the president, and the secretaries of state and defense) regularly and routinely raised the issue in discussions with foreign counterparts.

Washington has engaged in a series of definitional debates on whether to extend its vital interests to matters that would indirectly affect territorial integrity and political independence. These efforts have had mixed success. Defining the political independence and territorial integrity of Europe and Japan as a vital interest was compelling, particularly after the tangible demonstration of commitment produced by a massive US effort to liberate Europe and defeat aggression in Asia, which included the use of nuclear weapons, followed by the creation of a formal defensive alliance, the stationing of significant forces and clear, sustained high-level interest. The Carter Doctrine proclaimed that the United States would use its military forces to defend oil resources in the Persian Gulf.[11] This did not deter Saddam Hussein from invading an oil-rich neighbor, nor did it deter Iran from creating a proxy-state ally in Lebanon, from seeking to expand its influence in Iraq, or from engaging in terrorism and in nondestructive actions against networks and satellites.

Nuclear deterrence created a degree of restraint and stability, as major powers were afraid of the potentially existential consequences of direct military action against the other. But an attack against a network or a satellite would not justify a nuclear response, certainly not against another nuclear power, and most likely not against a non-nuclear power given the stigma attached to nuclear weapons' use. Ruling out a nuclear response limits deterrence. Anything less than an existential threat or a threat against truly vital interests will not have a deterrent effect. Deterrence lies at the intersection of credible threat and vital interests and neither is present for space or cyberspace.

> *Anything less than an existential threat or a threat against truly vital interests will not have a deterrent effect.*

If opponents had a similar interpretation of vital interests, if they believed there was a credible threat of serious retaliation for attacks against vital US interests, and if they believed an attack would be attributed to them, it might be possible to deter them. To date, however, no cyberattack has threatened vital interests. Instead, cyber incidents have generated little more than complaints. Opponents similarly may suspect that the United States will not start World War III if there is a nondestructive attack on a satellite.

Washington could shape opponent calculations by making specific statements on when and how it would respond to attacks on satellites or on networks. A Soviet invasion of Europe would trigger the use of nuclear weapons, either massively or flexibly, on Soviet forces, installations and leadership. This was a clear threat, publicly enunciated, linking explicit actions against vital interests to explicit (and immensely damaging) consequences.

Developing the same clear linkage will be more difficult for satellite and cyberattacks. What is the appropriate and proportional response for an attack against something less than a vital interest? Does retaliation create the risk of escalating conflict into other domains? If one assumes a degree of caution by major powers that have less tolerance for risk than other classes of opponents, one could expect to see the use of temporary and nondestructive attacks against satellites, and disruption of military computer networks rather than cyberattacks on civilian critical infrastructure in the American homeland. Opponents can manage the risk of escalation by observing implicit limitations on attacks while still gaining military advantage. If the opponent is in extremis, even these limitations may be discarded. Cyber and space capabilities are attractive targets that offer asymmetric advantage. The United States cannot make credible threats to deter nondestructive attacks, and in conflict, the value of ASAT attacks to an opponent may outweigh perceived risk unless Washington threatens a truly disproportional response.

The construction of a credible deterrent will be difficult in these circumstances. An explicit or implied deterrent threat to stop citizens from committing cybercrimes or military force would ensue will provoke either outrage or ridicule. The same is true for the threat of retaliation for nondestructive ASAT attacks, as jammers located in the attacker's national territory are immune in peacetime from military response. Tit-for-tat exchanges, especially if they involve nondestructive and temporary effects, are more likely to irritate than deter, and could easily escalate any confrontation or conflict.

> *For threats against space and cyber assets, there is a gap between credible threat and proportional response.*

International convention and law place constraints on how armed force can be used and thus limit the ability to make credible threats. Nations have the right to use force (consistent with the laws of armed conflict) in self-defense against destructive or coercive acts that threaten their territorial or political integrity. In international practice, espionage is not considered to be the use of force and a threat to use force in response to espionage is not credible. It would also, as noted above, be an unusual and unprecedented step to use military force in response to espionage – a precedent the United States, itself, might not wish to see created. In light of these constraints, opponents are unlikely to find the threats intended to deter as being credible.

For threats against space and cyber assets, there is a gap between credible threat and proportional response. Proportionality, which limits the use of excessive force in response to incidents and provocations, limits the kinds of threats that can be made. How much force is excessive is, of course, a judgment to be made by political leaders, taking into consideration their concern for international opinion, their own values and their assessment, with their military advisors, of the political and security consequences of the use of excessive force.

If one accepts the premise that only the threat of truly damaging retaliation has a deterrent effect, and if a truly damaging retaliatory threat can only be credibly made in response to an attack that involves the use of force and poses an existential threat or threatens serious harm to national interests, one has identified the threshold below which deterrence will not work. ASAT and cyberattackscyberattacks that do not pose existential threats or immense harm to vital interests, and thus neither deter or are deterrable. We routinely overestimate the effect of cyberattacks, which cause only limited physical damage, can be uneven in their effect, and are offer more opportunities for remedial action than kinetic attacks. Risk and benefit are asymmetric and favor the attacker.

> *Risk and benefit are asymmetric and favor the attacker.*

The use of nuclear weapons in the Cold War rapidly became binary; the choice for Washington and Moscow was use or non-use. Many analysts viewed escalation control as a fiction. Others maintained that once the nuclear threshold was crossed, leaders could engage in graduated nuclear attacks or limited nuclear war without this escalating uncontrollably into exchanges that posed an existential threat.[12] ASAT and cyberattacks, with their more limited effects, do not face the same taboo on use, nor do they generate the same fear regarding first use.

The Cold War clarified there were classes of actions that were not deterred by nuclear threats. Opponents with different cultural backgrounds, less experience in international relations and with a higher tolerance for risk might miscalculate the threshold of action that would trigger a forceful response. The likelihood of miscalculation is greater with the broad range of opponents the United States now faces.

> *ASAT and cyberattacks, with their more limited effects, do not face the same taboo on use, nor do they generate the same fear regarding first use.*

Declaratory policy is the best tool for shaping opponent perception of risk and credible threats. The declaratory statements of nuclear deterrence were robust, delivered by the president or the secretaries of defense or state. At their core they linked specific and immensely damaging responses to specific opponent actions. They explicitly laid out US capabilities to inflict unacceptable destruction. Observable programs and expenditures underpinned US statements. These explicit statements did not prevent opponent testing of the limits of deterrence, particularly at the periphery of vital interests, nor did they deter actions that fell below the threshold of the use of force, but they provided a degree of clarity that made it easier for opponents to calculate risk and redlines.

General statements delivered in national strategies without presidential or cabinet secretary-level reinforcement do not have the same effect. National strategies tend to be vague purposely and are not associated clearly with consequences. Ambiguity in deterrent threats, often held up as strategically artful, actually may encourage opponent miscalculation and lead to greater risk taking. Take, for example, the Obama administration's declaratory policy for space, issued in 2010:

> *The United States will employ a variety of measures to help assure the use of space for all responsible parties, and, consistent with the inherent right of self-defense, deter others from interference and attack, defend our space systems and contribute to the defense of allied space systems, and, if deterrence fails, defeat efforts to attack them.*[13]

It is unlikely that the threat to "employ a variety of measures" strikes fear into the hearts of opponents. Imprecision is defended as necessary since giving opponents explicit redlines would tell them what they could do with impunity. This ignores the likely conclusion that opponents, judging from their actions, had already deduced an implicit redline: that in peacetime, Washington will do nothing against actions that fall below the threshold of the use of force. While Washington believes that imprecision reinforces freedom of action, opponents may judge that the generality of US declaratory policy reflects a deeper indecision as to how Washington will respond to malicious actions against satellites.

Declaratory policies for cyberspace are similarly imprecise. The first general declaration had weight as it was delivered in a groundbreaking speech by President Barack Obama in May 2009.[14] In this speech, the President said that cyberspace would be treated as a 'strategic national asset" where the United States would "deter, prevent, detect and defend against attacks." Although general, this was an important first step. It was followed, however, by an international strategy for cyberspace in May 2011 that stated:

> *When warranted, the United States will respond to hostile acts in cyberspace as we would to any other threat to our country. All states possess an inherent right to self-defense, and we recognize that certain hostile acts conducted through cyberspace could compel actions under the commitments we have*

with our military treaty partners. We reserve the right to use all necessary means – diplomatic, informational, military, and economic – as appropriate and consistent with applicable international law, in order to defend our Nation, our allies, our partners, and our interests. In so doing, we will exhaust all options before military force whenever we can; will carefully weigh the costs and risks of action against the costs of inaction; and will act in a way that reflects our values and strengthens our legitimacy, seeking broad international support whenever possible.[15]

The mass of caveats that open and close the declaratory statement – "when warranted," "appropriate and consistent with international law," "exhaust all other options before military force," "carefully weigh the costs of action" – undercut its deterrent value. Most of these caveats are self-evident, they detract from the clarity of the statement and opponents could easily misinterpret or undervalue the implied threat.

Then-Secretary of Defense Leon Panetta made the clearest declaratory statement on cyberattacks in an October 2012 speech.[16] Panetta said that if the United States detected an imminent threat of cyberattack that would cause significant physical destruction or kill American citizens, it would take preemptive action. In nuclear parlance, this is the equivalent of "launch on warning." His statement was directed against Iran, which was then engaged in a series of massive denial of service attacks – the most basic form of attack – against major US banks and a telecommunication company.[17] It is telling that, while the Iranian activities subsided for a brief period, they soon resumed and were expanded to include probing of US critical infrastructure companies for exploitable vulnerabilities. Tehran did not cross the threshold set by Panetta and, judging from continued Iranian actions, the threat did not deter nondestructive attacks or intrusive preparations for attacks that could disrupt or destroy.

This partial record suggests that in peacetime, opponents will likely estimate that an action that does not rise to the level of the use of force and some physical destruction will not provoke or justify a military response by the United States. Cyber espionage or cybercrime, for example, falls below the threshold set by international law that would justify a military response. A military response to espionage would be unprecedented in international affairs, as nations do not regard espionage as an act of war or as the use of force. The risk, of course, is that an opponent with a different cultural background, less experience in international relations and with a higher tolerance for risk might miscalculate the threshold of actions triggering responses. The likelihood of miscalculation is greater given the diversity of potential opponents Washington now faces, and miscalculation also limits the scope of deterrence by affecting the credibility of any deterrent threat.

The risk of US retaliation using its general military capabilities is sufficient to deter destructive attacks in peacetime. It is unlikely, however, that opponents can be deterred from attacking US space or cyber systems once conflict is initiated. In conflict, an opponent may calculate that the losses to the United States from attacks on satellites or networks outweigh the risk of retaliation or of escalation. Washington can effectively deter major military operations against itself and its allies, but we can deter little else because the cost-benefit ratio has changed in ways unfavorable to deterrence.

A CHANGED TECHNOLOGICAL ENVIRONMENT

The technological environment has changed in ways that erode the ability to deter. In contrast to nuclear deterrence, cyber and ASAT weapons are less destructive and in most cases, much more readily available. The cost of acquisition and use is lower. Unlike nuclear attacks, where attribution is hard to avoid, attribution in both space and cyberspace is difficult, especially if the attacks are well planned. Attackers who believe they are anonymous will have a sense of impunity. Anonymity makes deterrent threats meaningless, since an attacker is likely to assume that the risk of detection and reprisal is low or nonexistent. What constitutes a "weapon" in both domains encourages doctrine and tactics that emphasize striking first, without warning. These factors work against stability and they undercut deterrence by reshaping perceptions of risk.

> *What constitutes a "weapon" in both domains encourages doctrine and tactics that emphasize striking first, without warning.*

The perception of the risk of retaliation depends to a degree on the destructiveness of the weapon used. Nuclear weapons, with their immense destructive capability, pose a threat that is difficult for a nation to ignore. A single nuclear weapon could destroy a city. No other weapon has the same destructive capacity. Nuclear weapons are sui generis, and the rules that apply to their use do not apply to other weapons technologies. Cyber "weapons" are less damaging than conventional weapons and ASAT weapons are so specialized and limited that they hold no extraordinary risk. Both ASAT and cyberattacks offer real military advantage, but neither is likely to threaten the survival of the state, nor do they pose unacceptable damage.
Truly destructive attacks still require a high degree of skill and investment, but less destructive attack capabilities are easily acquired, and because they do not involve the

use of force, carry less risk in their use. Sophisticated cyberattacks (like the Stuxnet virus that was directed against computers involved in the Iranian nuclear program) require research and advanced coding capabilities, but basic cyberattack tools are widely available. Similarly, kinetic or directed energy attacks against satellites require a level of resources that restrict their use to a few nations, but some nondestructive ASAT weapons, such as jamming, hacking and other techniques, are more easily obtained. In both cases, non-state actors as well as states have access to the low-end weaponry.

There are similarities between space and cyberspace that affect the applicability of deterrence. In both domains, the United States faces multiple opponents, and both are marked by extensive use of covert activities and by low-level friction, e.g., friction that stays below the level of the use of force. This potential for nondestructive "attack," lowers the risk of action and makes deterrence more difficult. For both domains, there is only a limited framework of norms or expectations for behavior, perhaps better developed for space activities, but still insufficient for providing a shared framework for countries to calculate the risk of an attack. The Soviet Union acknowledged having nuclear capabilities – it was in its national security interest to do so. Acknowledgement made serious discussion possible. In contrast, China denies possessing cyberattack and ASAT capabilities, making serious discussion impossible.

While there are similarities in the space and cyber domains, there are also divergences. Space is a mature technology; cyberspace continues to evolve. In particular, technological change will reduce the burden of attribution for cyberattack. A reduced ability to attack covertly will in some but not all circumstances change opponent calculation on the utility of cyberattack in peacetime. Cyber infrastructures do not face the same physical constraints that make it difficult to harden satellites against attack. Over time, opponents will face reduced covertness and harder targets in cyberspace. In contrast, technical measures are unlikely to reduce significantly satellite vulnerabilities. Vulnerability in cyberspace is also becoming more symmetrical, as many nations become dependent upon computer networks, while the United States remains asymmetrically vulnerable in space because it depends upon space more than its opponents. In cyberspace, for all but the most isolated economies, global digital networks have become the central economic tool for nations. While it is possible to insulate national networks to a degree, both China and Iran are as vulnerable to disruption as the United States. Autarkic, backward, economies, like that of North Korea, are the exception.

ASYMMETRIC VULNERABILITY AND ASYMMETRIC RISK

Deterrence is less effective in an environment where the United States has more to lose than an attacker. Nuclear deterrence depended in part upon symmetric perceptions of vulnerability. Each side essentially held the other's civilian population, military forces and economic infrastructure hostage. This risk symmetry is now lacking, particularly for space assets. If an opponent interferes with an American satellite and Washington responds in kind, the United States will run out of targets before the opponent does.

While all nations have vulnerabilities that can be exploited, particularly with peer or near-peer opponents, the US military is much more dependent upon information, networks and space assets than likely opponents, making attacks on these US systems irresistible. In an ASAT exchange, US military capabilities could be severely damaged, while the effect on China, which operates very few satellites, would be marginal. China, Russia and Iran (if it further develops its capabilities) could derive considerable benefit from attacking US space capabilities while Washington would derive only marginal benefit from attacking theirs. This suggests that deterrence in space or cyberspace cannot be domain limited and will require threats in other domains, i.e., an attack on US satellites could lead to an attack by US forces on terrestrial targets, raising risks of misinterpretation and escalation in conflict.

There is a natural US tendency to approach vulnerability from an apolitical and technological point of view. This involves assessing the chances that a weapon can reach its target and the damage expectancy once it arrives. This may not be how opponents assess vulnerability. Mao Tse-tung's famous statement (to Indian Prime Minister Jawaharlal Nehru in 1954) on how "the deaths of 10 or 20 million people [from an atomic bomb] is nothing to be afraid of"[18] was, in good measure, bluster, but it also may have reflected the views of a leader who was demonstrably willing to sacrifice millions of lives to achieve a goal. Overconfidence and underestimation of risk by new opponents cannot be ruled out.

During conflict, opponent calculations will be based on different assumptions about opportunities and risks, assumptions that have been shaped in part by US statements before conflict. Opponents will seek to gain military advantage and defeat US forces. The benefits of attacking and disrupting the foundations of the US informational advantage – computer networks and satellites – will be readily apparent to them. Opponents may be tempted to use such attacks in the initial phases of conflict, particularly given the benefits of surprise. Unlike nuclear weapons, first use against cyber and space assets does not bring with it the risk of rapid escalation to an existential conflict, as was the case with nuclear weapons, nor are there powerful taboos against use.

Opponent goals and expectations for conflict will shape the decision to use cyber and ASAT attacks. A desire for a quick victory over deployed US forces will encourage more extensive use of cyber and ASAT attacks. If the conflict is not going well, opponents may seek to ratchet up the level of attacks or to threaten attacks against the US homeland in an effort to manage and constrain US options. If they believe the United States poses an existential response to their regime, inhibitions against use, particularly against civilian targets in the US homeland may be discarded. If the United States has engaged in cyberattacks that the opponent sees as disproportional, it will also reduce inhibitions. The common themes are that information assets are a legitimate target and an area where an opponent will be tempted by the belief that an attack will provide asymmetric advantage. In conflict, opponents will not be deterred from calculating that attacks on networks or satellites are attractive and worth the risk.

AN UNSTABLE ENVIRONMENT

Strategic stability was a characteristic of deterrence based on mutual and symmetric vulnerability. Nuclear deterrence assumed a relationship between stability and vulnerability, where balancing mutual vulnerabilities created a stable strategic environment. The overwhelming nature of the nuclear threat meant these weapons did not have to be used to demonstrate that hostile actions could be costly. Washington could "manage" the conditions for stability by ensuring a rough equivalence of forces that produced and maintained symmetric vulnerability, so that the Kremlin never perceived a moment when the benefits of direct attack outweighed the cost.

> *In conflict, opponents will not be deterred from calculating that attacks on networks or satellites are attractive and worth the risk.*

Deterrence is inherently less stable in a multipolar environment than in a bipolar one. In some circumstances, efforts to pursue deterrence in a multipolar environment might actually be destabilizing, as inexperienced opponents misinterpret threats intended to deter. Threats in deterrence are conditional – if X happens, the response will be Y – but opponents may not understand this conditionality or may discount it, given their perception of US intentions and the continuing resonance with foreign audiences of earlier US statements as to how it would dominate and deny space and cyberspace to opponents. Selective or deficient listening is very difficult to overcome absent regular dialogue. Given differing sensitivities and levels of cognition among multiple opponents, a deterrent message could easily be misinterpreted.

> *Deterrence is no longer a sufficient goal for strategy.*

This is not a stable situation. Opponents are disinclined to accept US dominance (what some would call "hegemony") or regional military presence. Opponents will engage in asymmetric challenges to gauge their effect and determine how far they can go without triggering a US military response. Opponents will seek to avoid direct military confrontation with the United States and use asymmetric modes of conflict. These asymmetric efforts gnaw at the fringes of vital interests and present a more complicated target for a deterrent response, as they involve an increased risk of collateral damage, the difficulty of calculating proportionality, and a more complicated decision-making process for determining responses. The United States can expect a continued period of challenge and testing as nations (and politically motivated groups) recalculate their relationships with other states and explore ways to constrain American power. Just as the nuclear deterrent did not deter adventures at the periphery, US space and cyber capabilities cannot be expected to deter indirect challenges.

CONCLUSION

Deterrence is no longer a sufficient goal for strategy. To paraphrase Sir Michael Howard, there is widespread doubt that a posture of deterrence, however structured, will be enough to prevent an opponent that accepts war as an instrument of policy and has built up a formidable arsenal from not only initiating but fighting through a conflict in the expectation of victory, whether the United States wishes it or not.[19]

If the question is whether the United States can apply concepts of deterrence developed for nuclear weapons to deter attacks on networks or space assets, the answer is no. In peacetime, opponents will avoid destructive attacks that would justify the use of force by the United States in retaliation. During armed conflict, the United States will not be able to deter or prevent attacks given different perceptions of risk by attackers that derive from the perception of asymmetric vulnerability. Opponents will stand to gain more than they expect to lose in any exchange.

Future conflict will certainly include cyberattacks and possibly attacks on satellites. The goal of American strategy should be to deny these attacks success in achieving their larger objective of gaining military advantage over US forces by disruption of cyber and space assets. The best way to accomplish this objective is to create the ability to fight and win even if attacked in the space and cyber domains. Planning and acquisitions must be based on the assumption that opponents will attack space and cyber assets and that the United States must retain the ability to deliver the services these assets provide and limit any degradation in overall performance.

> *The goal of American strategy should be to create the ability to fight and win even if attacked in the space and cyber domains.*

A second objective for strategy is to shape and constrain the use of cyberattack to influence opponent calculations during conflict. The development of agreed international norms could define constraints and escalatory thresholds and shape wartime use of cyberattacks by making it easier for opponents to calculate risk. Broad international acceptance of norms could lead opponents to choose targets or modes of attack that hold less political risk. Multilateral understandings on acceptable behavior would increase the political risk of an attack and might justify retaliation.

Just as the use – and even the threat of use – of nuclear weapons has been stigmatized,[20] stigmatizing certain space and cyberattacks, or attacks against certain classes of targets, could reduce the risk of these attacks being launched. Stigmatization might be harder to create, as cyberattacks do not produce the moral repugnance that the planned use of nuclear weapons created, and the United States might, in the case of cyberattack, wish to preserve freedom of action to use these techniques.

The absence of a visible cyber or space "arms race," where nations publicize the development of new capabilities in order to change opponent calculations of the benefits of military action, suggests that in practical terms, deterrence now plays a subsidiary and supporting role, confined to a few specialized and unlikely kinds of conflict. Nuclear weapons are no longer the focus of warfare. They exist, serve some symbolic function and perhaps cancel out their use by adversaries. Perhaps as a result, new forms of conflict have gained prominence in which classic concepts of deterrence have little value. Taking Brodie's point on the utility of military force, the intent of building strategic arms was to deter. Now, adversaries build weapons designed to foil deterrence. The arms race was a kind of implicit bargaining between opponents, where one side's deployments or programs led to a countering effort to preserve stability. Maintaining a rough parity drove investment and planning. Now, countries build cyber and space weapons for warfighting advantage.

Improving defensive capabilities, constructing a normative framework that creates political disincentives for satellite and cyberattacks, and building in operational robustness that limits the benefit an attacker could gain, would all change opponent calculations in ways favorable to the United States. None of these steps entail repeating the Cold War experience of building offensive capabilities whose threatened use would deter attack.

This essay questions whether the strategies and concepts developed for nuclear deterrence can be usefully applied to other kinds of conflict. Nuclear weapons are uniquely destructive, and the bipolar global conflict was a unique political moment in international affairs. In this context, deterrence made sense, but these conditions do not exist for space or cyberspace. Deterrence, like Alfred Thayer Mahan's decisive battle between fleets of battleships, may be an artifact of strategy from an earlier era that political and technological change has overtaken and made instructive, but not actionable.

1. Reuters, "China jamming test sparks US concerns," USA Today, Oct 5, 2006, http://usatoday30.usatoday.com/tech/news/2006-10-05-satellite-laser_x.htm.
2. Ian Traynor, "Russia Accused of Unleashing Cyberwar to Disable Estonia," The Guardian, May 16, 2007, http://www.theguardian.com/world/2007/may/17/topstories3.russia.
3. Bernard Brodie, ed., *The Absolute Weapon* (New York: Harcourt Brace, 1946), 76.
4. A good account of this can be found in Keith B. Payne's *The Fallacies of Cold War Deterrence and a New Direction*, (Lexington, Ky.: University of Kentucky Press, 2001).
5. Dwight D. Eisenhower, *The White House Years: Mandate for Change*, (Garden City, NY: Doubleday, 1963) 453.
6. Foreseen by Herman Kahn, who believed the ability to deter would decline as smaller, less reliable nuclear powers emerged.
7. Dean Cheng, "Chinese Views on Deterrence," *Joint Forces Quarterly* 60, 1st quarter (2011): 92-94, http://www.ndu.edu/press/chinese-views-on-deterrence.html.
8. Robert McNamara, "Mutual Deterrence," speech given in San Francisco, Sept. 18, 1967, http://hawk.ethz.ch/serviceengine/Files/ISN/102970/ipriadoc_doc/d755811f-248e-48f1-bbe0-06c1cba0c559/en/1415_McNamara_MuturalDet.pdf.
9. United Nations Charter, Article 2.4, http://www.un.org/en/documents/charter/chapter1.shtml.
10. Jean Pictet, ed., 'The Geneva Conventions of 12 August 1949. Commentary" Volume IV, http://www.loc.gov/rr/frd/Military_Law/Geneva_conventions-1949.html.
11. Jimmy Carter, "State of the Union Address," Jan. 23, 1980, http://www.jimmycarterlibrary.gov/documents/speeches/su80jec.phtml.
12. See Lawrence Freedman, *The Evolution of Nuclear Strategy* (London: McMillian,1981); Robert E. Osgood, *Limited War: The Challenge to American Strategy* (Chicago: The University of Chicago Press, 1957).

13. Office of the President, *National Space Policy of the United States of America* (2010) (Washington, D.C.: The White House, June 28, 2010) 3, http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.
14. Barack Obama, "Remarks by the President on Securing our Nation's Cyber Infrastructure," Washington, D.C., May 29, 2009, http://www.whitehouse.gov/the-press-office/remarks-president-securing-our-nations-cyber-infrastructure.
15. Office of the President, *International Strategy for Cyberspace (2011)* (Washington, D.C.: The White House, May 2011)14, http://www.whitehouse.gov/sites/default/files/rss_viewer/international_strategy_for_cyberspace.pdf.
16. Leon E. Panetta, "Remarks by Secretary Panetta on Cybersecurity to the Business Executives for National Security," New York City, Oct. 11, 2012, http://www.defense.gov/transcripts/transcript.aspx?transcriptid=5136.
17. The Associated Press, "Panetta hints Iran behind Gulf Cyberattacks," CBS News.com, Washington, D.C., Oct 12, 2012, http://www.cbsnews.com/8301-202_162-57531088/panetta-hints-iran-behind-gulf-cyberattacks/.
18. Li Zhi-Sui, *The Private Life of Chairman Mao* (New York: Random House, 1994) 195.
19. Michael E. Howard, "On Fighting a Nuclear War," International Security (Spring, 1981) 3-17, http://wiki.victorybriefs.com/downloads/0816/Howard_81_On_Fighting_a_Nuclear_War.pdf.
20. Sahr Conway-Lanz, *Collateral Damage: Americans Noncombatant Immunity and Atrocity Aafter World War II* (Oxford, UK: Routledge, 2006); Nina Tannenwald, "Stigmatizing the Bomb: Origins of the Nuclear Taboo," International Security 29 no.4 (2005): 5-49.

Deterrence and Crisis Stability in Space and Cyberspace

By Bruce W. MacDonald

Deterrence and crisis stability require continuing US access to the military and commercial information streams both generated in and transmitted through space. Stability is reinforced when the incentives for an adversary to initiate offensive actions against one's space assets, or to escalate the scale of offensive actions if some level of offense is already underway, are outweighed by the disincentives to do so. Stability is strengthened by the ability to absorb at least modest perturbations to the status quo without those perturbations amplifying over the course of an ongoing crisis or conflict. "Parochial stability" might be defined as circumstances in which one state enjoys stability with regard to space operations, but the state's adversary does not. Parochial stability might then enhance escalation dominance for the parochially stable state, but not lend itself to deterrence and crisis stability because major space powers are unlikely to allow parochial stability for a potential foe. The very essential contributions of space assets as both an economic and military force multiplier ensure that any major power would not allow a competitor to attain, much less sustain, dominance in this domain.

How might the United States and China achieve deterrence and crisis stability in space under current and foreseeable circumstances? Deterrence and crisis stability rest on the balance of actual and potential offensive and related defensive capabilities between the two major space powers. Deterrence stability in space is affected by the dynamics of offensive and defensive force acquisition programs. Crisis stability, a subset of deterrence stability, is affected by perceived incentives and disincentives to undertake provocative or palliative behaviors and actions during a crisis. Deterrence and crisis stability in space operations are similar in some respects, but are also different from the nuclear domain. Deterrence stability overall, and crisis stability in particular, are highly desirable features for US security interests in the space domain, and generally desirable for cyberspace as well, given the considerable and growing economic and military benefits the United States derives from what can be termed space-enabled information services (SEIS) and the larger information services of cyberspace. Accordingly, strengthening our understanding of the dynamics of space deterrence and space stability in crisis situations is an essential national security task.

In a crisis, the decisions made by the United States and others on whether and how to use space control and cyber assets will play a major role in determining whether or how a crisis escalates. Understanding deterrence and crisis stability in space and cyberspace, accordingly, should be a high priority national security objective, yet we know very little about crisis behavior in space and cyberspace. To begin with, there fortunately have been no crises of note in space to extrapolate from, and while space war games offer insights, they too often rush through the crisis phase of the game to get to the conflict. In almost all such games, the important crisis period gets short shrift and is often viewed as little more than a necessary but minor prelude to the main event. Yet this is precisely the part of the exercise that should be a key focus of attention. Understanding the dynamics of the space domain in a crisis is essential to understanding how to maintain deterrence and crisis stability in space and how to avoid a potentially costly and lethal space conflict, or even larger full-scale war. This is not to downplay the importance of space war games, but rather to emphasize that more – perhaps separate – attention needs to be paid to the crisis phase. There is a rich vein of information to be mined from "crisis games," where the emphasis would be on understanding what behaviors, decisions and actions prove to be escalatory or de-escalatory. But much more needs to be done, including helping to frame the features that would lead to more informed and informative crisis games for space, in addition to war games.

> *we know very little about crisis behavior in space and cyberspace.*

This essay seeks to illuminate some dimensions of the strategic landscape of space, provides an overview of the dynamics of crisis stability in space, and identifies factors that would influence behavior in the space domain in a crisis or actual conflict. Of particular interest are behaviors that enhance or detract from deterrence stability in space, and some elements of cyberspace, too. Understanding how space deterrence functions or fails in a crisis, and factors that strengthen or weaken it, might enhance understanding of how best to shore up deterrence in a crisis, and how to prevent unwanted, uncontrolled escalation should conflict break out. It also could build upon current US space policy and strategy to inform peacetime decision-making on space behavior, space acquisition and strategic war-gaming. At this early stage in the development of stability concepts for space (and cyberspace), drawing in part from stability concepts from the nuclear domain, this essay necessarily raises far more questions than it resolves.

STABILITY IN THE SPACE DOMAIN

From an analytical perspective, space is strongly linked to cyberspace, given that the military and economic benefits of space are overwhelmingly about information, either directly generated in space or transmitted through it. Space war games and studies have repeatedly demonstrated this space-cyber connection, making it important that the cyber dimensions of space behavior be considered as well. The task of understanding the dynamics of the space and cyber domains is greatly complicated by the onrush of ever-advancing technology that re-sculpts the strategic landscape of both space and cyberspace. Technological change was and is a feature of the strategic nuclear environment, but the pace of change is arguably much faster in the space and cyberspace domains. From an analytical perspective, it is useful to begin looking at crisis stability purely within the space domain, but it would be a serious mistake to stop there. Cross-domain interactions seem almost unavoidable, other than possibly in a highly localized tactical situation.

Space assets, and the communications and cyber links that enable them to function, are the means by which essential national security information is either generated, transmitted or both. This information is the lifeblood of US conventional military superiority and plays a key role in US strategic nuclear posture as well. As such, these space-related assets represent extraordinarily appealing targets to adversaries in any future conflict, and their relative vulnerability could provide dangerously attractive incentives in a crisis to pre-empt, escalating to war. Similar incentives exist in cyberspace. It is not surprising that China's People's Liberation Army (PLA) would want the capability to interrupt the rivers of information and services that US space assets provide. This information allows American military decision-making, weapons and warfighters to be far more effective than in the past, vital advantages across the spectrum of potential conflict with major benefits to US security interests.

As China and others increase their space capabilities, their vulnerabilities in space will also grow as the margin of US operational advantage in space diminishes. It is possible that the United States will never become embroiled in a crisis with China, Russia or another major space power in years to come, but it would be risky to assume so. Greater understanding of the landscape and dynamics of deterrence and crisis stability in the space domain, and their interdependence with the cyber domain, need to be explored.

The importance of stability in the space domain has been recognized for some time, as in the Strategic Posture Review Commission, led by former Secretaries of Defense William Perry and James Schlesinger, that urges in its 2009 final report that the US "develop and pursue options for advancing US interests in stability in outer space."[1] The 2010 US Space Policy issued by the Obama administration also "recognizes the need for stability in the space environment."[3] But what are the primary threats to deterrence and crisis stability in space?

SEIS lie at the heart of US military superiority and are an essential force multiplier. These space assets are quite vulnerable and hard to defend. Consequently, that which greatly enhances military power in space will also remain quite vulnerable, at least to near-peer[s] competitors in space. The strategic implications of this situation are troubling, and made more so by the advancing technology of the space and cyber domains.

The immense destructiveness of nuclear weapons, coupled with the likelihood of uncontrolled escalation if the nuclear threshold were crossed, has been a stabilizing factor. Offensive military "counter-space" capabilities are less destructive and less terrifying. Consequently, there is a greater likelihood of the potential use of space weapons, coupled with the potential advantages that could accrue to whichever party uses them first in the early stages of a transition from a severe crisis to open conventional conflict between major space powers. Unlike in the nuclear domain, there is no assured second-strike capability at present for warfare in space comparable to the presence of ballistic missile-carrying submarines at sea. Indeed, there are no weapon systems of any kind deployed in space, which would make offsetting efforts to deploy them extremely destabilizing. Deterrence and crisis stability in space could be reinforced if vital space-enabled information services could be made so resilient to attack (through disaggregation or, less likely, active defense) that they could continue to function sufficiently after absorbing a major first strike. These conditions are hardly likely in the near- to mid-term, constituting a major difference for deterrence and crisis stability between the space and nuclear domains.

There is an inherent risk of strategic instability when relatively modest increments in offensive counter-space capabilities raise great discomfort to potential adversaries. There is also a serious risk of crisis instability in space when "going first" pays off – destroying an adversary's satellites while raising great difficulties for retaliating in kind. Indeed, a high strategic payoff from pre-emption virtually defines the meaning of crisis instability. No one can claim certainty about what would happen in a crisis, but the potential for deterrence and crisis instability seems high and is likely to grow.

Both the Bush and Obama administrations have declared in their space policies that American space assets are a "vital national interest," in recognition of the extraordinary and growing US military and economic dependence on them.[2,3] This is a new feature of US national security policy and reflects the rapidly evolving strategic environment of the early 21st century. The vulnerability of vital national interests in space presents an enduring challenge for deterrence and crisis stability. The US dependence on space seems to require offensive and defensive counter-space capabilities to respond in kind to attacks on vital national interests and to reinforce deterrence, but the nature and extent of these assets are veiled. In particular, US doctrine and strategy are unclear about when, how and under what circumstances to employ offensive counter-space capabilities.

STABILIZING AND DESTABILIZING ACTIONS

With conventional US military power so dependent upon SEIS, there would be substantial incentives in a deep crisis for a near-peer or a peer competitor to attack US military space infrastructure. The United States would likewise have certain incentives to execute offensive counter-space operations in such circumstances. Resisting the temptation to strike first may be virtuous but could be strategically unwise, since going first could offer many advantages, while absorbing preemptive strikes, with the attendant degradation of military capabilities, is likely to be militarily and strategically unsound. The PLA appears to be well aware of this dynamic, based on doctrinal writings.[4] Consequently, in a developing crisis, there are built-in incentives for escalation. A major unknown is how survivable a country's offensive space capabilities would be after absorbing the full force of an adversary's first strike. A key consideration is the extent resiliency can be built into SEIS assets that could retard the degradation of space-enabled capabilities. Strikes by adversaries with limited space capabilities could be addressed in traditional ways.

As technology advances, options for interfering with, disrupting or destroying information streams in space or supporting space systems likely will increase. Providing protective or defensive options for US space assets should be pursued where appropriate, but most analysts presume that offense will retain a decided advantage in space over defense, unless very highly resilient, highly decentralized and affordable space systems can be developed in the future. In the nuclear domain, the inability of defense credibly to blunt offense generally was seen as stabilizing – but not until both superpowers achieved assured second strike capability in the 1960s. Even then, arms race and crisis stability proved elusive. In the space domain, the pursuit of assured second strike capabilities will be more elusive and more destabilizing.

The United States has an overriding interest in maintaining the safety, survival and proper functioning of its space assets offering profound military, civilian and commercial benefits. Even a space conflict in which the United States is a bystander could result in severely adverse collateral effects. A peaceful, stable space environment would allow the United States to remain the primary beneficiary of what space can offer. The United States also seeks deterrence and crisis stability. These goals are not obtainable easily, because China has its own interests to pursue and has the means to prevent the attainment of US parochial stability.

> *In the space domain, the pursuit of assured second strike capabilities will be more elusive and more destabilizing.*

A properly crafted system of space management must be viewed as valuable by both the United States, China and all major spacefaring nations. This system will be hard to create, and harder to maintain during crises than in peacetime. Indeed, maintaining crisis stability will be the crucial test of whatever architecture can be constructed. Maintaining crisis stability in space seems more likely if "shock absorbers," such as operating norms, are codified and become respected parts of the fabric of peacetime space operations. Crisis stability is less likely if operating norms are not in place when a crisis occurs.

The United States might enjoy potential benefits from some offensive operations in space, but these benefits must be weighed against the value of weakening a norm of non-use of force against space assets in a domain in which the United States enjoys great benefits. Another factor affecting national decisions about initiating offensive actions against an adversary's space assets is that no country has any significant experience in this realm of conflict. The possibility of unintended consequences and major disruptions from infrastructure interdependencies may pose disincentives, but not an absolute barrier to initiating offensive actions in space.

In any crisis it is possible that, despite the preferences of the parties involved, conflict appears inevitable. One central challenge for major space powers is to build firebreaks of sufficient resilience and effectiveness so that adversaries can avoid conflict due to miscalculation or misunderstanding. Escalatory steps, if required, ought to be taken based on an accurate understanding of unfolding events, not on the basis of misunderstandings and misperceptions. This is important both for addressing planned as well as unplanned or inadvertent conflict – if such firebreaks are possible.

While it is clear that the rules of nuclear deterrence and crisis stability do not translate directly into the space, much less cyber, domains, this does not mean that deterrence and crisis stability are therefore irrelevant – only that they exist in different forms and with different, sometimes starkly different, behaviors. Take, for example, the projected use of tactical vs. strategic nuclear weapons. War games have repeatedly indicated that any use of nuclear weapons, whether short or intercontinental range, would likely result in uncontrolled escalation and general nuclear war. In contrast, it seems entirely possible that the United States and China, for example, might engage in offensive counter-space operations in limited, localized or tactical ways. Barriers to limited, offensive counter-space activities could well be more porous for states that do not have the wherewithal to inflict catastrophic damage to space assets, or in scenarios in which major spacefaring nations oppose states with limited counter-space capabilities.

Figure 1 is a rough sketch comparing and contrasting the space, cyber, nuclear and conventional conflict domains according to several strategic planning considerations. While hardly authoritative, the chart suggests that the variation across domains is pronounced, and that lessons learned from one domain should not be applied to other domains without careful review and analysis.

Feature	**Nuclear**	**Space**	**Cyber**	**Conventional**
Limited Use Is Escalatory?	Yes	No, but	No, but	No
Major Benefit to First Use?	Modest	Yes	Yes	Modest
Knowledge of Adversary Arsenal?	Yes	Yes, but	No	Yes
Understand Effects?	Yes	?	No	Yes
Are There Cascading Effects?	Yes	Likely	Yes	Modest
Rate of Environment Change	Modest	High	Very High	Modest
Arsenal Vulnerability	Modest	?	?	Modest
Secure Reserve Force?	Yes	?	?	Modest
Role of Uncertainty	Modest	High	Very High	Modest

Figure 1

At what point does the limited or tactical use of offensive counter-space capabilities or cyber weapons take us to a crisis tipping point, where miscalculation, misunderstanding, Murphy's Law and/or Mother Nature – the modern-day Four Horsemen of Strategic Apocalypse – trigger a crisis, small-scale conflict or show of force that escalates into all-out strategic conflict? This is one of the great unknowns of deterrence and crisis stability in space, worthy of greater analysis and simulations.

The dynamics of nuclear deterrence are well understood from Cold War experience. This is not the case for strategic warfare in the space and cyber domains. Offensive counter-space capabilities are difficult to count or compare in detail, their indirect effects are substantial yet difficult to quantify and capabilities are almost never discussed in public. Space weapons are less visible, and cyberweapons nearly invisible. Over time, the two nuclear superpowers developed venues to discuss strategic arms control and related issues. There is an obvious need for discussions of deterrence and crisis stability in the space and cyber domains, if only to develop a common language and understanding of the issues involved, as well as to provide insight into how major powers understand these concepts and view the opportunities and pitfalls these weapons pose.

> *In a crisis, the single most important non-military action that can be taken is to have open and reliable channels of communication with an adversary.*

In a crisis, the single most important non-military action that can be taken is to have open and reliable channels of communication with an adversary. Communication channels in a crisis have a better chance of success if there is a prior record of constructive interaction, and when leaders are familiar with each other and conversant with the issues involved. This is one of the arguments in support of high-level pursuit of an international code of conduct and the development of rules of the road among major space powers. In the nuclear domain, communication was advanced through information exchanges and dialogues relating to strategic arms control negotiations and scientific exchanges. These avenues are absent in the US-China bilateral relationship, and some are even enjoined by congressional intervention. In many ways, the space domain reflects the nuclear domain in the 1950s, when sporadic dialogue gradually led in subsequent decades to more frequent contact, understanding and, eventually, collaborative ventures. The United States and the Soviet Union had no better alternative than to engage in this journey. The same is true for the United States and China at present.

Signaling in a crisis is important, and is more useful if accompanied by a "diplomatic libretto" to ensure that what is communicated, whether by an action taken or not taken, is understood by the adversary. Signaling is subject to the same kinds of interpretation and misinterpretation in the space arena as it has been in the nuclear domain. Just as elevated nuclear alert levels accompanied the Cuban missile crisis and the 1973 Middle East war, so, too, may signaling in space accompany a significant crisis between the United States and China. Nuclear signaling during the Cold War conveyed in unmistakable terms the seriousness of the stakes involved. In space the differential between signaling and messaging may be much smaller, even though the escalatory potential could be high.

> *Upgrading the readiness of kinetic-energy ASAT capabilities in a crisis is unlikely to be kept secret, even if national leaders wished to do so.*

This, too, suggests the value of a space code of conduct and rules of the road among major space powers. Absent clear understandings grounded in routine practices and clarified through channels of communication, signaling in space can be misread by leaders who are mistrustful of one another and inclined to engage in worst-case analysis. Likewise, unintentional or false signals, as in benign equipment failures, also can be destabilizing in a crisis, as participants scrutinize the entrails of every significant event for their meaning and intent. One urgent task for spacefaring countries would be to establish a libretto for space signaling, as well as choreography for the transmission of such signals. The value of these measures ironically was demonstrated by a North Korean space launch in 2013. The launch was in clear violation of UN Security Council resolutions, but North Korea announced the launch in advance, giving the flight path and its purported intent as a space launch. When this test was conducted, and the missile flight path matched the announced flight path, worst cases were discounted, even though this "space launch" contributed to the North Korea's development of an intercontinental-range missile.

Upgrading the readiness of kinetic-energy ASAT capabilities in a crisis is unlikely to be kept secret, even if national leaders wished to do so. Such preparations are likely to intensify a crisis, even if they were viewed as militarily prudent measures. During a deep crisis, the testing of an ASAT weapon or a weapon system that could readily be employed as an ASAT would be a seriously destabilizing act, even if explicitly meant as a signal. This is in some ways analogous to the portentous signaling option of a demonstration nuclear shot to show resolve, often discussed although never exercised.

Rendezvous and proximity operations increasingly will become a feature of space operations. Certain kinds of on-orbit operations could enhance space deterrence and crisis stability, such as replenishment of consumable and on-orbit repairs, by making the satellites at least somewhat more resilient. Other kinds of on-orbit operations, such as activity in the vicinity of adversary space assets, could be destabilizing. Prior notifications, rules of the road and a code of conduct might help clarify peaceful or malicious intent. Keep-out zones adjacent to foreign spacecraft might also be advisable. There is no obvious analogue to such operations in the nuclear domain.

Offensive space counterforce targeting of key space infrastructure supporting nuclear forces would be extremely destabilizing, suggesting preparations for nuclear conflict, whether true or not. In the same way, cyber warfare targeting supporting nuclear infrastructure would be highly destabilizing. Asymmetries of space-based capabilities could pose additional complications and dangers. For example, the United States places high value on its missile warning satellites, while China as yet has no comparable capabilities. Breaking contact with, or attacking, communication links between national command authorities could have the most severe escalatory potential in a crisis or limited warfare.

THE STRATEGIC LANDSCAPE OF SPACE

The military and commercial value of space resides in the information generated or transmitted in this domain. Viewed from this perspective, conflict seems unlikely to remain purely in the space domain except at the very lowest level of hostile activity, e.g., jamming of an individual satellite. Given the dependence of US conventional military power on space systems, the latter is likely to be a priority target for Chinese military action in the event of a conflict. Rapid escalation could ensue. Here we enter the realm of speculation, as there are no prior cases of space being the lynchpin of deterrence and crisis stability.

The single most stabilizing aspect of the strategic nuclear balance was and is the existence of secure second strike capabilities. Sea-based strategic capabilities or capabilities residing in Triads introduced an important stabilizing element into the strategic nuclear balance, assuring that no matter how powerful a nuclear first strike was, the attacker would still suffer a devastating retaliation. There does not appear to be an analogue to the space or cyberspace domains, constituting major obstacles to deterrence and crisis stability in space. Indeed, in space there appear to be tangible advantages to striking first. Creating stabilizing equivalents to assured retaliatory capabilities – or partial equivalents – appears to be a priority task for deterrence and crisis stability in space to be attained and strengthened.

For most of the nuclear era, the United States and the Soviet Union had a good idea of the strategic offensive and defensive forces arrayed against each other. This is much less true for offensive and defensive counter-space capabilities. Major powers will have difficulties gathering solid information on the types and status of deployed counter-space and cyber capabilities. This means that uncertainty, bluffs and risk aversion might all be highly prominent features of crises in space and cyberspace, perhaps even more so than in the nuclear domain. Electronic warfare has a relatively long history in the annals of modern conflict, where radar jamming and other steps often have been used for tactical advantage. This may well continue to be the case in space at a purely tactical level. Small-scale use of jamming capabilities has already occurred, including Iranian jamming of Eutelsat, as well as other instances of interference.[5,6] These actions need not be destabilizing or cause for escalatory action, depending on target type and scale of use. However, since uncertainties will remain concerning the boundary between non-escalatory and escalatory use, even small-scale acts of interference could lead to crisis instability, especially between major powers.

> *Resilient and redundant space assets will be key factors in deterrence and crisis stability in space.*

Resilient and redundant space assets will be key factors in deterrence and crisis stability in space. Modest efforts in this regard might be sufficient to address relatively unsophisticated space and cyber threats, but not against major spacefaring nations, where system resiliency, alternative back-up systems and other means to preserve core SEIS capabilities in the event of a conflict will be required. The extent to which resiliency and redundancy can be better embedded in space systems will play an important role in reducing incentives to deter and enhance crisis stability. As China seeks greater military reach farther away from its territory and concomitant global situational awareness, the PLA necessarily will need to rely more on space to meet its informational requirements. This growing space dependence will be a complicating factor in PLA contingency planning, as greater reliance on space almost certainly will be accompanied by greater vulnerability in this domain. The PLA, as well as the Pentagon, will be obliged to seek more resilient and redundant space capabilities.

In any crisis that threatens to escalate into major conflict, political and military leaders will be plagued by uncertainty about the effectiveness of their plans and decisions.

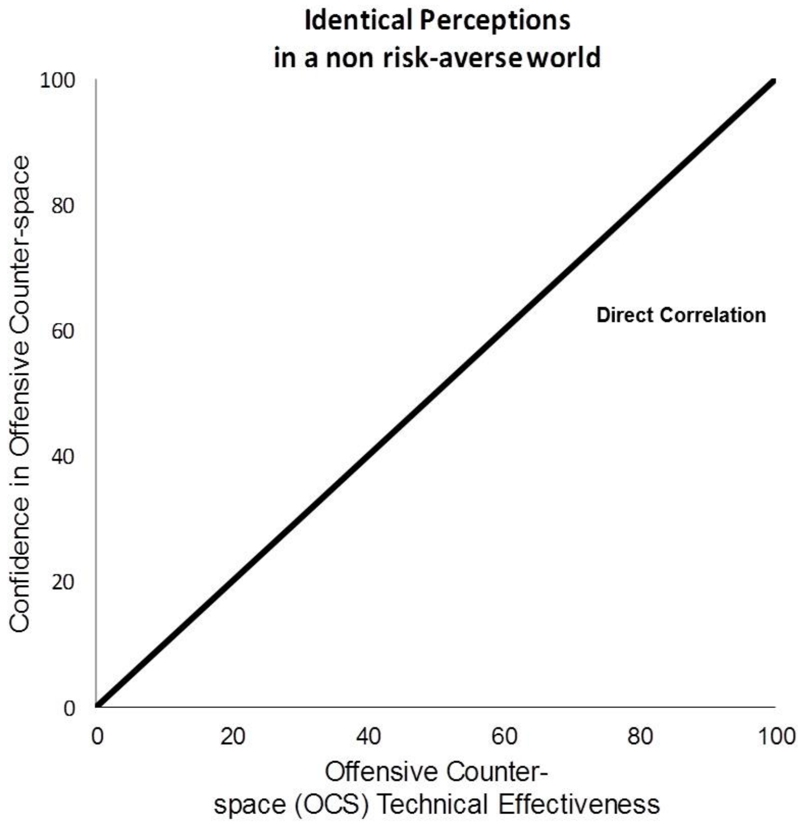


Figure 2

Uncertainty will be compounded as conflict involves new domains such as space and cyber warfare, where weapon effectiveness is relatively untested and uncertain, infrastructure interdependencies are unclear, and damaging effects against one's adversary could result in damaging effects against oneself or one's allies. Unless the stakes are very high, neither side is likely to want to take a huge gamble with their countries' well-being in a "single cosmic throw of the dice," in Harold Brown's memorable phrase.[7]

The very newness of warfare in the space and cyber domains, coupled with risk averse, worst case assessments, could lead space adversaries into a situation of hysteresis, where each is self-deterred by their own uncertainty of success. This is shown conceptually in Figures 2 and 3 for offensive counter-space capabilities, though it applies more generally. Where uncertainty and risk aversion are absent, there would be no difference between likely offensive counter-space performance and confidence in per-

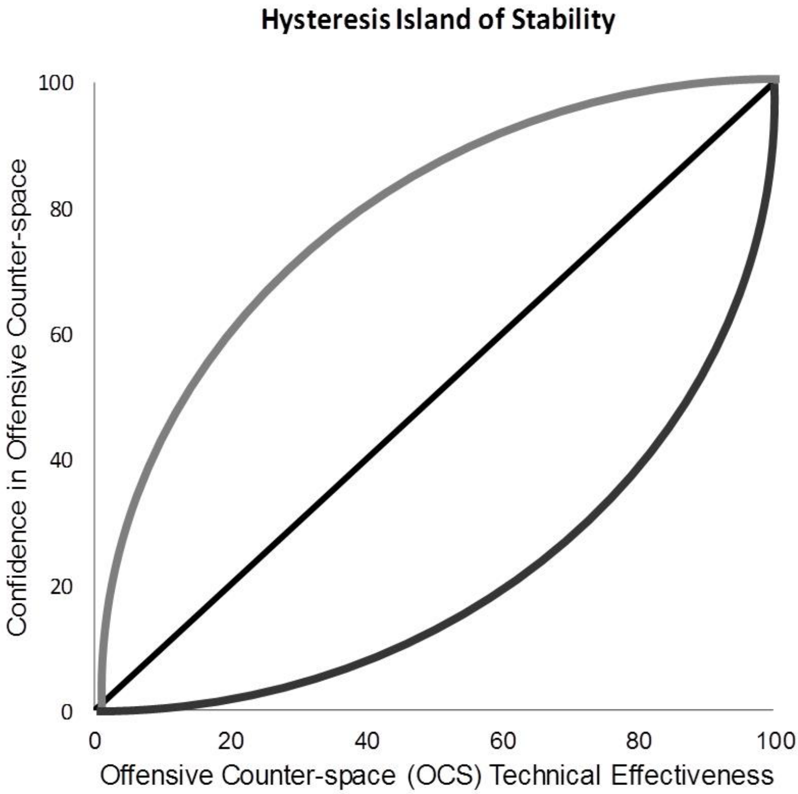


Figure 3

formance – a straight-line 1:1 correlation, as in Figure 2. In contrast, uncertainty and risk aversion create a gap in this relationship – or an island of stability – as shown in Figure 3. How resilient or robust this phenomenon may be is uncertain, but it may provide at least some stabilizing influence in a crisis.

In the nuclear domain, the immediate, direct consequences of military use, including blast, fire and direct radiation effects, were appreciated at the outset. Nonetheless, there were large uncertainties about and under-appreciation of the collateral, indirect and climatological effects of large-scale use of such weapons. In contrast, the immediate, direct effects of major space conflict are not well understood, and potential indirect and interdependent effects are even less understood. Indirect effects for large-scale space and cyber warfare are virtually incalculable, making conflict in these domains between major powers somewhat akin to the use of highly virulent biological weapons, where the use of such weapons could end up causing as much damage to the user as to the adversary, imposing a certain level of self-deterrence.

IMPLICATIONS FOR US SPACE SECURITY INTERESTS

The United States would be wise to exercise great caution in considering the first strategic use of offensive space capabilities, because it obtains more benefit from space than any other country. If offense predominates, why initiate offensive counter-space operations in a domain where one has the most to lose in warfare against a major power? The use of offensive counter-space operations for tactical gain against a much weaker adversary would probably provide relatively little incremental benefit. Using offensive space capability in this scenario would therefore probably not be necessary, because military action by other means would likely be sufficient to defeat the opponent. Moreover, it is in the US national security interest to reinforce a norm of non-use of offensive counter-space capabilities. Undercutting this norm requires careful evaluation, and only if the likely benefits substantially outweigh likely drawbacks.

> *Worst cases of space and cyber warfare may be avoidable, just as nuclear warfare was avoided during the Cold War.*

If localized conflict with a near-peer competitor is already underway, then tactical, non-strategic and preferably reversible offensive space capabilities are likely to be considered for employment, but only in a selective battlefield manner where there are clear benefits substantially greater than those obtainable by alternative force options, and where indirect collateral effects are understood and deemed insignificant. Presumably, an adversary would apply the same calculus in decision- making. Given the uncertainties involved, a 55-45 cost-benefit ratio would probably not be good enough, while 90-10 might well be, depending on confidence in the measurement and assuming cost-benefit ratios can be evaluated. Unlike nuclear crises and nuclear weapons' use, where any use is likely to result in uncontrolled escalation, the situation will be more muddied in a space and cyber conflict. Escalation control could be problematic, substantial levels of casualties and economic damage could result from the indirect effects of all-out space and cyber war, and the military consequences of being cut off from SEIS would likely be very substantial. Furthermore, it would be questionable to assume that all-out space and/or cyber conflict would not spread to more traditional domains as well, raising the specter of nuclear as well as conventional conflict.

Each class of space assets has different value to both attacker and defender, with resulting "differential deterrence" and war-fighting implications. For example, it is important to differentiate among orbits, as there are more options to attack more quickly in low Earth orbit than in geosynchronous orbit. An attack against space assets directly related to strategic nuclear forces would clearly have different implications than an attack against a civilian communications or GPS satellite. In the same way, a reversible attack against a space asset does not have the same implications as an irreversible attack against the same asset. High fidelity space situational awareness capabilities are required to enable and confirm the nature of such attacks. Differential deterrence appears to be intrinsic to the space domain, based on target value; this appears to be true in the cyber domain as well. The employment of tactical attacks of a temporary or reversible nature would have the effect of lowering the deterrence threshold, thereby making the transition from crisis to conflict at least marginally more likely.

Worst cases of space and cyber warfare may be avoidable, just as nuclear warfare was avoided during the Cold War. The United States, China, Russia and other developed countries should have a common interest in avoiding strategic conflict in the space and cyber domains, which would threaten crippling direct and indirect economic consequences in a way that the world has never experienced. Beijing, which has struggled to achieve levels of economic security previously unknown in Chinese history, should be reluctant to risk the economic advances of two generations of progress, as well as the promise of more progress to come. The demographic and other challenges facing China, where a high rate of economic growth has been deemed necessary to tamp down political unrest, would seem to offer cautionary notes against space and cyber warfare. Chinese leaders might, however, throw caution to the wind if they feared dire consequences for a failure to act in a severe crisis, or if they were unable to maintain tight control over a PLA that may not share their calculus of decision. China's lack of a National Security Council-type decision-making body leaves open the possibility of a civil-military divide in a deep crisis.

As was the case during the Cold War nuclear standoff, massive "bolt-out-of-blue" space or cyberattacks are unlikely. Generally speaking, it would be prudent to assume that any seeming offensive action of more than nuisance impact is a one-off, possibly accidental or even rogue event, or at most a way to demonstrate capabilities and send a signal. Some modest increase in defensive alert level also would be prudent, accompanied by a priority inquiry at an appropriate level to the suspected country of origin for explanation. This would be easier to accomplish if there would be some modality comparable to the US-Russian Risk Reduction Center or Hotline in existence, particularly between Washington and Beijing. Improved communication channels might usefully accompany an international code of conduct for responsible spacefaring nations, if one can be agreed to, and is worthy of consideration even if it not.

The US alliance structure can promote deterrence and crisis stability in space, as with nuclear deterrence. China has no such alliance system. If China were to engage in large-scale offensive counter-space operations, it would face not only the United States, but also NATO, Japan, South Korea and other highly aggrieved parties. Given Beijing's major export dependence on these markets, and its dependence upon them for key raw material and high technology imports, China would be as devastated economically if it initiated strategic attacks in space. In contrast to America's nuclear umbrella and extended deterrence, US allies make a tangible and concrete contribution to extended space deterrence through their multilateral participation in and dependence upon space assets. Attacks on these space assets would directly damage allied interests as well as those of the United States, further strengthening deterrent effects.

CONCLUSION

This chapter has sought to address the question of deterrence and crisis stability in space. The author's intention has been to stimulate further thought rather than to preach verities. These pages strongly suggest the need for greater understanding and analysis of the challenges of preventing and responding to deterrence challenges in the relatively new strategic domain of space. Offensive counter-space capabilities and cyberweapons have many characteristics that are fundamentally different from nuclear weapons, but they all share at least one characteristic in common: They are most definitely not just "one more weapon in the arsenal." Because assets in space constitute and reflect vital national interests, offensive counter-space capabilities have strategically significant characteristics. Better understanding of the strategic landscape of space and cyberspace, is an essential 21st century priority.

This preliminary review barely scratches the surface of the critical issues of crisis instability of space. Among the many further questions that should be addressed are:

- Could limited offensive counter-space attacks remain limited, or would they inevitably escalate into all-out space conflict? Can firebreaks between actions that are likely to remain limited and those that run serious risks of escalation be determined and clarified? Will the United States, much less its potential adversaries, have the necessary space situational awareness to address such questions?

- How much offensive counter-space capabilities does the United States require to have a credible space deterrent capability? Will other forms of military power, including cyber warfare capabilities, be sufficient?
- What kinds of offensive counter-space capabilities are most stabilizing and effective in meeting US military objectives?
- How much secrecy is advisable for US offensive space and cyber warfare capabilities? What are the advantages and disadvantages of secrecy, and how do they affect stability and deterrence?
- What are the primary interconnections between space and cyber warfare, and how do they affect deterrence and crisis stability in space?
- How do China, Russia and other major spacefaring nations view deterrence and crisis stability in space? Looking ahead, how will this shape China's space doctrine, acquisition, strategies and diplomacy?
- Do "temporary and reversible effects" make space conflict less damaging while guarding against unwanted escalation? Do temporary and reversible means of space warfare lower the threshold for space conflict?
- Are asymmetrical US responses to space attacks that create casualties credible? How does this affect their deterrent value?
- Will space deterrence hold if one side is close to what it perceives as a defeat?
- What is the impact of third (and Nth) countries on space deterrence?
- How will rapidly evolving cyber warfare capabilities affect deterrence and crisis stability in space? How will they affect space-based capabilities?
- Does space declaratory policy affect behavior in a crisis? If so, how? What are the tradeoffs between clarity and ambiguity, especially with regard to firebreaks and "red lines?"
- How might the "fog of crisis" affect space crisis decision-making?
- What are the positive and negative effects of combining military and civilian functions on spacecraft?
- What are the relative merits and drawbacks of space-based vs. surface-based offensive counter-space capabilities? What are their advantages and disadvantages for deterrence and crisis stability in space?
- How will the growing capabilities of the United States, China and others to conduct on-orbit proximity operations on satellites affect deterrence and crisis stability in space?
- What new technologies are most likely to have significant impacts on deterrence and crisis stability in space?

As this incomplete list of questions demonstrates, there are large uncertainties regarding deterrence and crisis stability in space, both at the strategic level – about likely behaviors of adversaries in a crisis or in actual conflict – and at a tactical level. Deeper understanding of the dynamics of likely space power behavior in a crisis and in conflict can be gained through analysis, simulations and other research tools. These steps are required to enable wiser decision-making, provide more clarity of US requirements in the space and cyber domains, and illuminate US decision-making on space, in peacetime and especially in crisis and conflict.

1. The Strategic Posture Review Commission, America's Strategic Posture: *The Final Report of the Congressional Commission on the Strategic Posture of the United States*. (Washington: United States Institute of Peace Press, 2009), 71, http://www.usip.org/sites/default/files/America%27s_Strategic_Posture_Auth_Ed_0.pdf.
2. The White House, *US National Space Policy* (2006), Washington, Aug. 31, 2006, http://www.whitehouse.gov/sites/default/files/microsites/ostp/national-space-policy-2006.pdf.
3. The White House, *National Space Policy of the United States of America (2010)*, Washington, June 28, 2010, http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.
4. Kevin Pollpeter, "PLA Space Doctrine" in Andrew S. Erickson and Lyle J. Goldstein, eds., *Chinese Aerospace Power: Evolving Maritime Roles* (Annapolis, Md.: Naval Institute Press, 2011), 50-65.
5. Oliver Luft, " BBC Accused Iran of Trying to Block Persian service," *The Guardian*, June 15, 2009, http://www.theguardian.com/media/2009/jun/15/iran-bbc-persian-service
6. Eutelsat Statement on Deliberate Jamming of Satellite Signals, Paris, Nov 17, 2011, http://www.eutelsat.com/news/compress/en/2011/html/PR%207611%20Iran/PR%207611%20Iran.html
7. Harold Brown, "Report of Secretary of Defense Harold Brown to the Congress on the FY 1979 Budget, FY 1980 Authorization Request and FY 1979-1983 Defense Programs," Jan. 23, 1978, 65, http://www.dod.mil/pubs/foi/logistics_material_readiness/acq_bud_fin/247.pdf

The United States and China in Space: Cooperation, Competition, or Both?

by Michael Nacht

> *"Relations between China and the United States need not – and should not – become a zero-sum game. For the pre-World War I European leader, the challenge was that a gain for one side spelled a loss for the other, and compromise ran counter to an aroused public opinion. This is not the situation in the Sino-American relationship. Key issues on the international front are global in nature. Consensus may prove difficult, but confrontation on these issues is self-defeating."*[1]
>
> \- Henry Kissinger

Any assessment of US-China relations in space should begin with a broader consideration of the overall bilateral relationship in the context of contemporary international relations. The Cold War ended more than two decades ago, roughly the same amount of time as the "inter-war" period between the end of World War I and the start of World War II. Strategies used in the first war were deadly ineffective in the second.

The current period is marked by three key characteristics that were barely evident during the Cold War: asymmetric capabilities and strategies among the key players; growing economic, political and technological interdependence; and a complex pattern of multi-polarity in which some states are more influential in certain spheres and less so in others.

Despite calls in some quarters for US retrenchment, Washington maintains deep involvement in virtually all the key security issues of the day, even after withdrawing from Iraq and the pending withdrawal from Afghanistan. More than a decade since 9/11, the US employs a wide array of military, diplomatic and economic tools to battle Islamic extremism. The United States cooperates with other major powers to implement this strategy, albeit selectively.

The United States has long-standing policies to thwart the spread of nuclear and other weapons of mass destruction, particularly the challenges posed by North Korea and Iran. In the former case, China plays an important role; in the latter, Russian influence and support is more pertinent. Because of their United Nations Security Council permanent member veto power, intense bargaining with Russia and China, however frustrating and limited in results, is a necessary feature of American diplomacy.

Wherever one turns – seeking stability in Pakistan, resolving the bitter civil war in Syria, opening new opportunities for trade and investment in sub-Saharan Africa and Latin America, resolving territorial disputes in the South China Sea – a complex pattern of cooperation and competition is evident in US-China relations. The bilateral economic relationship, of course, dominates global attention. According to the US-China Business Council, the United States had an $83 billion trade deficit with China in 2001 that grew to $266 billion in 2008, dropped in 2009 during the financial crisis, and stood at $295 billion in 2011. As of 2013, China owned more than $1.2 trillion in US treasury bills, notes and bonds. It owns 8 percent of all publicly held US debt, third largest behind the Social Security Trust Fund and the Federal Reserve.

> *intense bargaining with Russia and China is a necessary feature of American diplomacy.*

These macroeconomic statistics have important domestic economic consequences as China's economy has grown and matured. Both nations now face serious economic challenges. A key issue that bridges the gap between economic and security concerns is, of course, cyber security. This topic was discussed in depth by the national leaders for the first time in June 2013, and a working group has been established to generate a regular dialogue that could lead to common understandings and rules of the road in the cyber domain. The magnitude and quality of Chinese penetration of US computer networks, both public and private, is a huge bone of contention between Washington and Beijing. Chinese efforts have led to unprecedented theft of US intellectual property, including design of advanced military systems. Chinese officials have claimed that, in the absence of codified rules, its behavior does not violate any laws.

In sum, the bilateral relationship is complex, marked by centripetal and centrifugal forces that are likely to result in cooperation, competition and even confrontation—what Nobel Laureate Thomas Schelling characterized more than 50 years ago as "mixed-motive bargaining." As both are nuclear weapon states, the shadow of mutual nuclear deterrence is always present, and, one hopes, serves as a cautionary element for the Chinese leadership.

WASHINGTON'S ASSESSMENT OF CHINA IN SPACE

Unlike cyber security issues, China's space activities have not prompted a broad level of public discussion and debate. US assessments have remained the province of a small community of specialists. China was the third country to launch a man in space in 2003 and has been accelerating its activities in space for the past decade. The Department of Defense May 2013 assessment of China's military capabilities noted that in 2012 China conducted 18 space launches and "expanded its space-based intelligence, surveillance, reconnaissance, navigation, meteorological and communications satellite constellations."[2]

The report stated that China seeks to "limit or prevent the use of space-based assets by adversaries during times of crisis or conflict."[3] Deputy Assistant Secretary of Defense for East Asia David Helvey noted that "China continues to invest in a multidimensional program to deny others access to and use of space."[4]

> *China continues to invest in a multidimensional program to deny others access to and use of space.*

The extent of China's commitment to space is clearly evident and is reflected in the following data:

- China launched six satellites for its Beidou navigation constellation in 2012 that completed a regional network as well as the in-orbit validation phase for a global network expected to be completed by 2020.
- In 2012 China launched 11 new remote sensing satellites that can perform civil and military applications. Its constellation of imaging and remote sensing satellites support military objectives by providing situational awareness of foreign military force deployments, critical infrastructure and significant political targets.
- China launched three communication satellites, five small experimental satellites, plus a meteorological and a relay satellite. China plans to launch 100 more satellites by 2015 including imaging, remote sensing, navigation, communication and scientific satellites, as well as manned spacecraft.
- China continues to develop the Long March 5 (LM-5) rocket intended to lift heavy payloads into space. LM-5 will more than double the size of the low Earth orbit (LEO) and geosynchronous orbit (GEO) payloads China is capable of placing into orbit. The Wenchang Satellite Launch Center located on Hainan Island is expected to be completed in 2013 with the initial LM-5 launch scheduled for 2014.

What is the strategy behind China's space activities? China has historically taken a long view of most strategic issues, and these steps are likely part of a marathon approach rather than a sprint. China's declared space expenditures – $3 billion from 1992 to 2005, $3 billion from 2006 to 2013 – may well be understated and are a fraction of the National Aeronautics and Space Administration's (NASA) annual budget of approximately $17 billion. But one must be very careful about Chinese pronouncements and about comparative budget estimates. It depends what can be purchased with what one spends.

It is plausible that China has a mix of domestic prestige, strategic, economic and political motivations. For domestic audiences, a sophisticated space program culminating in a manned lunar landing by the end of the decade would be a huge political boost for the regime and ratification that its focus on economic modernization without political reform is the right course.

> *China's space activities are likely part of a marathon approach rather than a sprint.*

Economically, China seeks to be a reliable and safe provider of launch services for humans and satellites. It has already launched communication satellites for Pakistan and Nigeria and a remote sensing satellite for Venezuela. If commerce in space is a wave of the future, as it surely seems to be, China seeks to be a major – if not the dominant – player.

The increase in Chinese space launches might be explained partly by the relatively short life spans of Chinese satellites. Experts note that they tend to last three to five years, compared to 15 for the United States. Moreover, China, with all its current activity, still launches fewer satellites per year than the United States. China's reconnaissance satellite resolution is thought to be about one meter. The commercially available GeoEye satellite resolution is better, at slightly less than half a meter.

Within Asia, China is competing with India and Japan, two neighbors with active programs and growing ambitions in space. Beijing has periodically experienced contentious relations with both states, and would benefit politically, economically, militarily and psychologically by out-competing New Delhi and Tokyo in space. Strategically and in the longer term, China is well aware that the United States relies on satellites for perhaps 80 percent of its communications and more than 80 percent of its intelligence gathering. By being able credibly to threaten US space assets, Beijing might seek to dissuade US intervention in a Taiwan or other East Asian crises. Destroying the US capabilities in space if deterrence fails could be determinative in conflict.

US officials explain Beijing's pursuit of a variety of air, sea, undersea, space, counterspace and information warfare systems as contributing to an anti-access/area denial [A2/AD] strategy. These pursuits are embedded in operational concepts, moving toward an array of overlapping, multi-layered offensive capabilities extending from China's coast into the western Pacific. The Pentagon seeks to counter China's A2/AD strategy by adopting measures that, if successful, would in fact, if not in name, reflect its own A2/AD strategy.

THE RELEVANCE OF THE SOVIET-AMERICAN RIVALRY

How relevant is the Soviet-American space rivalry during the Cold War to the emerging Chinese-American space competition? The Soviet Union launched the first Earth-orbiting satellite into a low Earth orbit in March 1957 and Yuri Gagarin was the first human to complete an orbit of the Earth in April 1961. These were traumatic Cold War events for Washington decision-makers and the US public. They led to a massive investment in science and engineering education, major attention to the military applications of space and the conversion of the National Advisory Committee for Aeronautics (formed in 1915) into NASA in 1958. NASA gained worldwide renown in successfully implementing President John F. Kennedy's initiative that culminated in the first human landing on the moon in July 1969.

Although there was clearly intense Soviet-American competition in building military assets for space, and there were periods of intense strategic competition in space during the Cold War – exemplified by President Ronald Reagan's Strategic Defense Initiative launched in 1983 to transition to a defense-dominated nuclear relationship, and Soviet efforts to counter it – space paled in comparison to the strategic nuclear arms competition. The Kremlin realized that it could not compete with the United States in terms of advanced space technology, and steered the rivalry where it could – toward strategic nuclear delivery vehicles – where it could maintain rough strategic parity with the United States.

The techniques employed by Washington and Moscow to reduce the dangers of their strategic competition and to keep it within bounds may have some relevancy for the US-China competition in space. The US-Soviet nuclear rivalry produced an extended diplomatic dialogue in which both sides began to converge on a common vocabulary. The completion of a series of nuclear arms control and reduction agreements did not always have a restraining effect – particularly at the outset of this process – but, over time, did place effective constraints on the pursuit of strategic advantage in this domain. A three-decade-long process of nuclear negotiations produced a large number of individuals on both sides who became very familiar with each other and with their thought processes and negotiating gambits. The Russian Federation's ambassador to Washington, Sergey Kislyak, has more than 25 years of arms control experience.

The Soviets and then the Russians, while maintaining an opaque strategy and secretive deployments, nonetheless came to accept intrusive on-site inspection and other cooperative monitoring measures because they perceived it to be in their political and security interests to do so. Indeed, as the Soviet and then the Russian economy deteriorated from the late 1970s through the end of the past century, nuclear diplomacy became Moscow's chief means of retaining its superpower status.

This experience bears little resemblance, at least so far, to the evolution of Sino-American strategic relations. Although there has been continuous diplomatic contact between Washington and Beijing since the historic Shanghai communiqué in 1972, China has consistently refused to engage in formal arms control discussions, citing its position of deep military inferiority. Although there have been numerous "Track II" dialogues on strategic issues between Chinese and American experts, the United States is a long way from establishing the sort of personal, linguistic and conceptual familiarity that developed between Moscow and Washington. Indeed, the joint Sino-American working group on cyber security established in 2013 is the first of its kind, and it is too early to assess its value. The absence of personal, linguistic and conceptual convergence is a centrifugal force in bilateral relations that increases the probability of misunderstanding, worst-case planning and miscalculation in crisis situations.

> *The Cold War experience bears little resemblance, at least so far, to the evolution of Sino-American strategic relations.*

Whereas the Soviet-American rivalry was global in character, the Chinese- American military competition is, as of now, regionally focused. Moreover, the Sino-American relationship is dominated by bilateral economic issues and complex interdependencies. These features were completely absent in Soviet-American relations. Thus, aspects of the emerging military competition, including in space, simply do not yet claim the priority that was consistently the case with Moscow. It is by no means clear whether the cyber and space issues will begin to produce more frequent and substantive interactive exchange.

OUTLINING ELEMENTS OF THE SPACE RIVALRY

The United States has long focused on three main objectives in space: defense of satellites, control of space, and facilitating the projection of force. As Bruce M. Deblois and his co-authors have noted,

> *Techniques available to protect US satellites include advanced technical means to overcome denial and deception, radiation hardening and shielding, command and data encryption, anti-jamming measures, and limiting orbital maneuvering … Techniques for denying an adversary the use of space [i.e., "space control"] … [include] denial and deception, electronic warfare, attacks on ground stations, micro satellites or space mines and ground-based projectile antisatellite weapons."*[5]

Force projection capabilities deployed in space, including space-based lasers, anti-satellite (ASAT) weapons, space mines, unmanned combat aerial vehicles and "brilliant pebbles," periodically have gained public attention, but have yet to be realized. In contrast, the potential for ground-based military systems to be used as ASAT weapons has been a fact of life for major spacefaring nations for many decades. A newer question is whether "rules of the road," codes of conduct or even formal treaties with China and other states will be a route to set norms relating to the use and deployment of some of these systems.

THE OBAMA ADMINISTRATION'S SPACE POLICY AND STRATEGY

The Obama administration, recognizing the rise of other major space powers, the primacy of the offense over defensive measures in space, the growth of private sector activity and unprecedented budgetary constraints, has issued several documents to articulate its position with respect to space activities.

The first of these is the National Space Policy issued in June 2010, a joint product of the Department of Defense and the intelligence community.[6] This document acknowledged that space has now become congested, competitive and contested. It is congested with more than 21,000 objects in orbit ranging from the most important satellites to the most trivial, but still lethal debris. It is competitive because of the growing number of states and private entities seeking to provide commercial services. And it is contested primarily because the United States, China and Russia use the domain to further their respective strategic and military purposes.

> *Space has become congested, competitive and contested.*

The Obama administration's space policy calls for energizing domestic industries; expanding international cooperation; strengthening stability in space through information sharing and other cooperative measures; increasing assurance and resilience of mission-essential functions by supporting infrastructure against disruption, degradation, and destruction; pursuing human and robotic initiatives; and improving space-based Earth and solar observation.

Among many other points, the Obama administration's space policy emphasizes the intent to maintain US leadership in space-based positioning, navigation and timing. Far more than his predecessors, President Barack Obama has emphasized the need for great cooperation and confidence-building while remaining committed to the central elements needed for the United States to use space for its national security objectives.

A follow-up National Security Space Strategy was issued in January 2011.[7] This document articulated a Department of Defense strategy for deterrence in space with four key elements:

1. Support the development of international norms of responsible behavior that enhance safety, security and stability in space.
2. Build coalitions to enhance collective security capabilities.
3. Deny the benefit of aggression by enhancing the resilience of space architectures and ensuring that US forces can operate effectively when space capabilities are degraded.
4. Be prepared to respond to an attack on US or allied space systems proportionally, but not necessarily symmetrically and not necessarily in space, using any or all elements of national power.

These elements constitute a mixed strategy that includes cooperative as well as unilateral measures.

In January 2012, the Obama administration moved further on the cooperative side. Then-Secretary of State Hillary Clinton announced that the United States would work with other nations to develop an international code of conduct for outer space.[8] Clinton added that "a code of conduct will help maintain the long-term sustainability, safety, stability and security of space by establishing guidelines for the responsible use of space."[9] But she emphasized that the US "will not enter into a code of conduct that in any way constrains our national security-related activities in space or our ability to protect the United States and our allies."[10]

> *The extent of Beijing's ambitions will determine whether deterrence succeeds in space.*

The European Union has led efforts for more than five years to establish a code of conduct in space, so far with limited results. On a different track, Russia and China have promoted at the United Nations Conference on Disarmament and elsewhere to secure adoption of a treaty called the Prevention of the Placement of Weapons in Outer Space and the Threat or Use of Force Against Outer Space Objects (PPWT).[11] After several years of discussion on this proposal, Moscow and Beijing have little progress to report.

DETERRENCE AND AMBITION

The United States is a status quo power. China is a rising power. The extent of Beijing's ambitions will largely determine whether deterrence succeeds or breaks down in space. The economic interdependence that characterizes Sino-American relations can have stabilizing effects. If, however, the Chinese leadership's fundamental objective is to replace the United States as the leading military Asian power, and perhaps the leading global power, while achieving status as the world's dominant economy, then considerable friction could result.

Space assets are likely to feature prominently in a Chinese A2/AD strategy, as well as a US strategy to deny Beijing an A2/AD strategy. In the event of crisis, both US and Chinese leaders must presume capabilities to disrupt and damage satellites. It will be up to political leaders to exercise or decline to use these options.

The United States is pursuing multiple paths to maintain space capabilities in the event of disruptive or damaging actions by a potential adversary, including greater resiliency of space systems. The four features of resiliency include developing international norms as a partial barrier to aggressive actions; building international partnerships so "an attack on one would be an attack on all;" revamping training and doctrine so the US forces can fight on once attacked; and maintaining a robust retaliatory capability against the attacker. Collectively the elements would serve to deter the initial attack or, if deterrence fails, respond with great military effectiveness. Potential US responses could occur across military domains, as the Chairman of the Joint Chiefs of Staff Martin E. Dempsey remarked in the context of Chinese cyber espionage against US economic targets:

> *I think what the president … would insist upon, actually, is that he had the options and the freedom of movement to decide what kind of response we would employ … That's why I say I don't want to have necessarily a narrow conversation about what constitutes war and cyber, because the response could actually be in one of the other traditional domains.*[12]

The US-China strategic competition, including rivalry in space, fully illustrates the characteristics of contemporary international politics. It is a struggle between asymmetric powers—a super power of long standing with powerful naval and air capabilities and great dependency on high technology assets in the space and cyber domains seeking to reinforce the status quo vs. a (becoming) near-peer rival with vast ground forces that seeks to alter the status quo by thwarting US capabilities and thus denying American military intervention in East Asian (and perhaps other) conflicts. This rivalry is situated amidst complex interdependencies and limitations, including limits of influence on neighbors.

In this context, cross-domain deterrence – the use or threat of use of action in one domain (i.e., land, sea, under the sea, air, space, cyber as well as economic tools and diplomatic measures) to thwart action in a different domain – will be given greater consideration. To be sure, cross-domain deterrence is not a new phenomenon. A recent obvious example is the use of economic sanctions and alleged cyberattacks against Iranian facilities aimed at dissuading Tehran and increasing the costs of continuing its nuclear weapon-related development program.

> *US-China strategic competition in space is a struggle between asymmetric powers.*

There are, however, inherent difficulties in pursuing cross-domain deterrence. US declaratory policy tends to be purposefully vague with respect to many national security threats in order to provide the president with a wide range of options. One cost of such flexibility might be confusion concerning the response to challenges to US national interests. An adversary might not know what to expect, be surprised by the response and might misinterpret the intent of the US reaction. Ignorance of the decision-making dynamics in Beijing by Washington and vice versa could lead to steps by either government intended to be de-escalatory that are viewed as escalatory. China's centuries-old strategic culture that values opaqueness to shield both strengths and weaknesses will make the process of anticipating adversarial response especially challenging.

An additional conceptual confusion, at least in Washington, is between "deterrence" – providing credible threats to dissuade an adversary from taking a particular course – and "compellence" – providing credible threats to persuade an adversary from pursuing a course already adopted. In the much-studied Cuban missile crisis, for instance, US policy was both to deter a missile attack in the Western Hemisphere while compelling the Soviets to withdraw missiles from Cuba. A US "side payment" of secretly agreeing to withdraw obsolescent Jupiter missiles from Turkey helped facilitate resolution of the crisis. Compellence tends to be much more difficult to achieve, perhaps since the adversary has already committed substantial resources to achieve a fait accompli.

CONCLUSION

It would be advisable and it is likely that the United States and China will begin to engage in deeper bilateral or multi-lateral discussions or negotiations that could establish certain codes of conduct in space. Slow but tangible cooperation would contribute to common understandings and thus reduce the likelihood of misunderstandings and surprise. At the same time, both sides are most likely to enhance offensive and defensive capabilities to seek military advantages as part of their overall strategies. The US-China relationship in space, as on the ground and at sea, will be a mix of cooperation and competition. Hopefully, as Kissinger reasoned, foolish actions will be avoided that could have profound negative effects on both societies.

1. Henry Kissinger, On China, (New York: Penguin, 2011), 523.
2. Office of the Secretary of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2013," May 2013, 9, http://www.defense.gov/pubs/2013_china_report_final.pdf.
3. Ibid.
4. Karen Parrish, "DOD Report on China Details Military Modernization," American Forces Press Service, May 6, 2013, http://www.defense.gov/news/newsarticle.aspx?id=119943.
5. Bruce M. Deblois, Richard L. Garwin, R.Scott Kemp, and Jeremy C. Maxwell, "Space Weapons: Crossing the Rubicon," International Security (Fall 2004): 55, 63.
6. The White House, *National Space Policy of the United States of America*, Washington, June 28, 2010, http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.
7. US Department of Defense, *National Security Space Strategy*, Washington, January 2011, http://www.defense.gov/home/features/2011/0111_nsss/docs/NationalSecuritySpaceStrategyUnclassifiedSummary_Jan2011.pdf.
8. Hillary Rodham Clinton, U.S. State Department Press Statement, "International Code of Conduct for Outer Space Activities," Washington, Jan. 17, 2012, http://www.state.gov/secretary/rm/2012/01/180969.htm.
9. Ibid.
10. Ibid.
11. For treaty text, see: *Treaty on Prevention of the Placement of Weapons in Outer Space and the Threat or Use of Force Against Outer Space Objects*, Feb 29, 2008, http://i.cfr.org/content/publications/attachments/PPWT.pdf .
12. Gen. Martin E. Dempsey, "Gen. Dempsey's Remarks and Q&A on Cyber Security at the Brookings Institut[ion]," Washington, June 27, 2013, http://www.jcs.mil/speech.aspx?id=1779.

U.S.-China Cooperation in Space: Constraints, Possibilities, and Options

By Brian Weeden

Outer space activities played a significant role in the Cold War relationship between the United States and Soviet Union, emerging first as a domain for intense political and military competition and potential conflict, and then becoming a venue for cooperation. The projected worst-case scenario of space conflict and nuclear warfare between the superpowers was avoided. Eventually space activities became an important tool for building stability and trust that enabled cooperation and a degree of friendship.

Will the Cold War pattern and outcome between the nuclear superpowers be repeated between the United States and China? Can the space domain help build mutual understanding and respect between Washington and Beijing, contributing to peaceful coexistence or perhaps even friendship? Or is the historical model of US-Soviet relations and space cooperation not applicable between the United States and China?

There is evidence that senior leaders in both the United States and China realize the potential for US-China cooperation in space to foster a positive relationship between the two countries. In 2011, US President Barack Obama and then Chinese President Hu Jintao issued a joint statement on strengthening US-China relations during a visit by Hu to the White House.[1] As one of the steps outlined in the statement, the two presidents agreed to take specific actions to deepen dialogue and exchanges in the field of space and discuss opportunities for practical future cooperation. The United States has also signaled its willingness to open a bilateral dialogue with China on space security issues.

> *The United States and China continue to test weapon systems that could be used to damage or destroy satellites*

There has been little progress to date beyond the joint statement. China so far has been reluctant to engage in a space security-focused dialogue with the United States, and some in Congress oppose any form of bilateral space cooperation with China. U.S. Rep. Frank Wolf, R-Va., had led efforts to restrict bilateral cooperation with China: The Fiscal Year 2011 Continuing Resolution prevents the National Aeronautics and Space Administration (NASA) or the White House Office of Science and Technology Policy from spending any federal funds on participating, collaborating or coordinating in bilateral cooperation with China.[2] Meanwhile, both countries continue to engage in national security and military space activities, including multiple tests of weapon systems that could be used to damage or destroy satellites, which have heightened concerns over a military competition in space.

The direction and mix of future US-China space competition and cooperation is far from settled. This essay outlines different types of bilateral space cooperation, if congressional restrictions against doing so were lifted, and if Washington and Beijing were willing to press forward with a space cooperation agenda. I discuss a bottom-up and a top-down approach for space cooperation. I advocate a comprehensive strategy for engagement in space with clearly defined goals and steps that mix in both bottom-up and top-down approaches, rather than the pursuit of a single cooperative space activity.

CATEGORIES AND CONSTRAINTS OF SPACE COOPERATION

Space cooperation between two countries can take many forms, with varying degrees of complexity and involvement. Thus, it is beneficial to begin by laying out broad categories of cooperation and understanding the advantages and disadvantages of each. A useful framework in this regard can be found in a 2008 report published by the Congressional Research Service (CRS) on options for US-China space cooperation. The CRS report outlines three categories of cooperation: information and data sharing, space policy dialogue and joint activities.[3] Information and data sharing involves exchanging data on matters such as the nature of the space environment with the goal of establishing a common operating picture and set of facts. Space policy dialogue is a more specialized form of data exchange that focuses on enhancing strategic communications between the two countries. The goal of space policy dialogue is to understand more accurately the other's views, concerns and intentions with the hope that it would lead to fewer cases of miscommunication and misunderstanding. Finally, joint activities are the most "hands-on" option and involve both countries agreeing to participate in a specific activity, usually by contributing money or other resources such as hardware or expertise. The goal of joint activities is usually to achieve an objective neither could achieve individually, to develop organizational experience in working together or to convey a political message regarding the bilateral relationship.

Defined in this way, the term "cooperation" is a bit of a misnomer in that it is not limited to just civil space activities between two space agencies. Space cooperation can be a much broader undertaking, more accurately defined as space engagement. It encompasses a wide range of activities in the civil, scientific and military domains, all aimed at building patterns of cooperation between two or more countries.
In the joint statement issued by Obama and Hu in 2011, the near-term action to

promote dialogue and exchanges in the field of space was to take the form of an invitation for the head of the Chinese Manned Space Engineering Office to visit NASA headquarters. This was in reciprocation for a visit by NASA Administrator Charles Bolden to China in 2010.[4] However, the Chinese trip never materialized because of budget injunctions imposed by the Wolf Amendment.[5] In the 2011 joint statement, the two sides also agreed to continue discussions on opportunities for practical future cooperation in the space arena, based on principles of transparency, reciprocity and mutual benefit. These three perfectly sensible principles are not easy to implement and present additional complications on the prospects for US-China space cooperation.

TRANSPARENCY

The United States has consistently pushed for greater transparency concerning China's decision-making process, budget and space policy. China is deliberately opaque on military capabilities in general, and space capabilities in particular. Opacity in decision making can be an effective way for a weaker state to deal with a stronger state. The United States may also be opaque to China, but for different reasons, as the abundance of information and diversity of viewpoints can lead to confusion abroad about US policy.

Transparency is even more challenging an issue because neither China nor the United States wishes to reveal military space capabilities or vulnerabilities. Furthermore, it is extraordinarily difficult for Washington and Beijing to distinguish between correlation and causation relating to military space decisions. It is often unclear whether national actions reflect a rational decision-making process of a government as a whole, organizational behavior within a government or "court politics" within a government.[6]

> *China is deliberately opaque on military capabilities in general, and space capabilities in particular.*

The US X-37B space plane serves as an example of the difficulty of divining intent, the lack of transparency and distinguishing between correlation and causation. The X-37B is a miniaturized, fully-automated version of the space shuttle that is able to stay on orbit for several months at a time. It could be used for either peaceful or offensive military purposes. The Pentagon will not describe specifically what the X-37B is doing on orbit nor provide details of its location while on orbit.[7]

Some outside observers have concluded that the X-37B is really a space weapons program, thus explaining the absence of transparency regarding its test program. This view is supported by writings in military journals on the value of a space plane as a tool to “defend and control” space and to enhance US space dominance.[8] This conclusion is almost certainly not the case, as there are significant technical limitations to many of the theorized capabilities of such a vehicle.[9] It is more likely the case that the secrecy surrounding the orbital location of the X-37B is a function of its use as a test bed for classified sensors for the National Reconnaissance Organization (NRO). Existing US policy requires any such spacecraft to have its orbital position classified.[10]

The 2007 Chinese antisatellite test serves as another example of the absence of transparency due to perceived national security imperatives. In January 2007, China used a ground-launched ballistic missile to destroy one of its own aging weather satellites, resulting in the creation of more than 3,000 pieces of trackable space debris. The event sparked significant concern and was held up as a sign of China’s insincerity in international discussions on space debris and the prevention of an arms race in outer space. Belated and conflicting public statements from Beijing suggested that the test was not coordinated with the Ministry of Foreign Affairs.[11] The China National Space Administration was due to hold a meeting of the Inter-Agency Space Debris Coordination Committee the following April to discuss the space debris mitigation guidelines that had been recently approved by the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). The meeting was canceled at the last minute and rescheduled to take place in Toulouse, France, in July 2007 where the Chinese delegation faced harsh questions from other international scientists.[12]

A study by Gregory Kulacki and Jeffrey Lewis, based on more than 80 interviews from individuals across the Chinese government, concluded that the decision to conduct the test was carefully vetted, with the full participation of other stakeholders, including representatives of the Foreign Ministry.[13] The details of internal decision making are not fully known, but it is likely that, as with the X-37B, conflicting public statements and the apparent lack of coordination was mainly a result of organizational behavior compounded by opacity.

The promotion of transparency in space operations faces considerable, but not insurmountable obstacles for the United States and China. Both spacefaring nations are already participating in several broader, multilateral discussions related to transparency on space activities. In 2010, the Scientific and Technical Subcommittee of UNCOPUOS created a formal Working Group on the Long-term Sustainability of Outer Space Activities.[14] The working group aims to produce a consensus report outlining voluntary best practice guidelines for all space actors to promote the long-term sustainable use of outer space. In 2011, the United Nations secretary general formed a Group of Governmental Experts (GGE) on Transparency and Confidence Building Measures (TCBMs) in Outer Space Activities.[15] The 15 international experts who make up the GGE, including experts from the US and China, have produced a consensus report outlining specific recommendations for TCBMs on space security issues. The report's recommendations will be considered by the Fourth Committee of the United Nations General Assembly during its annual plenary in October.[16]

The European Union (EU) is leading discussions on an International Code of Conduct for Outer Space Activities (ICOC). If an ICOC can be agreed upon, it is likely to include transparency measures, including notifications, consultations and exchange of space policies.[17] The EU has briefed spacefaring countries, including China, which thus far has not endorsed the EU's draft text. Beijing has, however, endorsed the report of the GGE, which includes support for the concept of an ICOC. The UNCOPUOUS and GGE are important initiatives to foster dialogue between the United States and China, as well as to help develop positive norms of behavior that can increase transparency of space operations.

RECIPROCITY AND MUTUAL BENEFIT

The Obama-Hu joint statement outlines reciprocity and mutual benefit as the second and third guidelines for future US-China space cooperation. This language strongly suggests that joint activities should include equal contributions by and provide tangible benefits to both parties. These guidelines impose constraints on the types of activities that might be considered because the United States and China have different levels of space capabilities and are currently pursuing different goals in the space arena.

> *United States and China have different levels of space capabilities and are pursuing different goals in the space arena*

The US space program, which received substantial investment during the Cold War, has receded to a lower sustained level. US space activities have long consisted of two major components – a very public civil space program undertaken by NASA and a much more secret program by the national security bureaucracy to conduct satellite reconnaissance of the Soviet Union. The human spaceflight portion of the civil space program focused monumental efforts on landing astronauts on the Moon. These activities culminated in the Apollo landings in the 1960s and 1970s. Total US launches peaked in the 1960s with nearly 80 space launches per year,[18] driven largely by national security space programs such as the Corona surveillance satellites as well as the Apollo program.[19]

Although launch rates slowed dramatically in the 1970s, the United States continued to invest heavily through the early 2000s in both civil and national security space capabilities. Human spaceflight focused on trips to low Earth orbit (LEO) and manned space stations using the shuttle. The non-human spaceflight portion of the civil space program included sustained robotic exploration of the Solar System, remote sensing of the Earth from space for climate monitoring and weather and a wide variety of scientific efforts. The national security space sector focused on developing a full spectrum of space capabilities to support national security objectives, including global satellite communications, remote sensing and precision navigation and timing (PNT).

> *US space activities are at a crossroads, facing debate over future goals and activities.*

Currently, US space activities are at a crossroads , with the number of orbital launches standing at approximately 20 per year.[20] Both the civil and national security programs face significant budget constraints and debate over future goals and levels of activity. With the end of the space shuttle program and retirement of the orbiter fleet in 2011, a vigorous debate has ensued about the future direction and goals of the human spaceflight program. Robotic exploration continues with recent successes such as the Mars rover landings, but faces continued budget cutbacks and schedule slips. The US military continues to modernize and upgrade its existing capabilities, but has been unable to field significant new capabilities due to budget pressure.

> *China is on a clear path to join the United States in possessing full-spectrum capabilities.*

In contrast, China's activities in space have been building slowly since the 1970s. Only recently has China begun to engage in the full spectrum of space activities across civil, scientific and national security sectors. China is now building many of the same space capabilities to support national security as the United States, including satellite-based PNT services and intelligence, surveillance and reconnaissance (ISR) capabilities. China is on a clear path to join the United States in possessing full-spectrum capabilities. China's human spaceflight program also largely has followed the same development path as those of the United States and the Soviet Union. Since 2001, China has developed the same set of capabilities needed to support human spaceflight as the United States and the Soviet Union demonstrated in the 1960s and early 1970s. All three countries took between 11.5 years and 13.5 years to accomplish these objectives, the only difference being the year they started.[21]

This difference in phasing of space capabilities is one of the factors complicating efforts by the United States and China to engage in reciprocal activities and to derive mutual benefit. As difficult as it was for the United States and the Soviet Union jointly to pursue the docking of their Apollo and Soyuz spacecraft, these programs were in similar phases. The Apollo-Soyuz docking in LEO, with the famous "handshake in space" between a cosmonaut and astronaut, is often cited as a model for major spacefaring nations to cooperate as well as compete in space. On a political level, the Apollo-Soyuz docking reinforced in a symbolic and visible way political intent to pursue détente in space as well as on the ground. On a practical level, Apollo-Soyuz allowed both countries to test and develop rendezvous procedures in space, a capability essential for their future manned space station programs.

> *United States and China are out of phase in terms of their human spaceflight programs.*

It is difficult to apply this model to the United States and China, which are out of phase in terms of their human spaceflight programs. China is in the midst of a 20-year plan to orbit its first continually-habitable space station. The United States is on the tail-end of its participation in the International Space Station and searching for a suitable human spaceflight mission outside of LEO in the wake of the space shuttle program. Some in the United States worry that human spaceflight cooperation with China would give China access to advanced technology or speed up China's program. China does not possess any compelling capability the United States lacks that could outweigh these concerns. There are also those within the United States and China who see any international cooperation as a burden, making projects more complicated, costly and prone to delays and failures.

BILATERAL OR MULTILATERAL COOPERATION

A final consideration is whether to pursue potential space cooperation between the United States and China in a bilateral or multilateral context. During the Cold War, the United States and Soviet Union were far and away the most advanced spacefaring nations. It made sense for the superpowers to engage primarily, although not exclusively, in bilateral cooperation. Other countries were involved in cooperative ventures, but they participated largely at the behest of Washington or Moscow. The space environment is markedly different from the Cold War, with many spacefaring nations enjoying the benefits of space technologies and capabilities. Eleven countries have demonstrated the ability to place an object in orbit, most recently Iran (2009), North Korea (2012) and South Korea (2013). More than 50 countries have operated or are currently operating at least one satellite. Three countries – the United States, Russia and China – have active human spaceflight programs, with India signaling interest in joining them.[22]

Many countries view space activities as a significant contributor to their socioeconomic well-being and to the utilization of natural resources, as a key part of their communications infrastructure, and as a means of fostering science and technology. A smaller, but growing, number of nations view space as a domain for providing critical national security capabilities. An even smaller subset of countries is engaged in or considering human spaceflight as a way to build prestige and enhance their regional or global power.

This diversity of capabilities and ambitions offers a spectrum of multilateral, cooperative space activities and opportunities. On one end of the spectrum are cooperative activities between technological peers or near-peers to accomplish a significant objective that none could accomplish individually, perhaps because costs are prohibitive for unilateral endeavors. The eventual shape of the ISS program is an example of shared costs.[23] On the other end of the spectrum are cooperative activities involving one advanced spacefaring country and a number of smaller, less-advanced spacefaring nations. These activities usually involve scientific research and largely are undertaken to foster diplomatic ties among the countries involved.

The United States and China already are engaged in a number of cooperative space activities, although they are almost entirely multilateral in nature. Both countries are part of the International Charter on Space and Major Disasters, a multilateral agreement to provide for the collaboration and dissemination of space-based remote sensing data to help respond to natural disasters. Both the United States and China are also part of the aforementioned multilateral UNCOPUOUS, GGE and ICOC deliberations. Washington and Beijing are involved in an international effort to share data on space weather to improve warning and prediction of significant geomagnetic storms that could disrupt satellites or ground infrastructure. Perhaps most intriguingly, the Alpha Magnetic Spectrometer (AMS-2), recently installed on the ISS to conduct research on dark matter, contains more than 4,800 pounds of Chinese-supplied rare earth magnets. This project is backed by a team of scientists from several countries, including China.[24] In deference to the Wolf Amendment, this space science initiative – even though it was multilateral and not bilateral in nature – was pursued under a contract with the US Department of Energy and not NASA.

The United States and China engage in bilateral space cooperation activities, but they are fewer in number and limited in scope. The US military currently provides warnings of close approaches that could result in a collision between Chinese satellites and other space objects, such as space debris, as part of a service the United States' offers to all satellite operators.[25] The United States and China also have held three rounds of a Track II technical exchange on space surveillance, modeled on a similar technical exchange between US and Soviet researchers that began in the 1990s. Space has also featured in recent bilateral security dialogues, although the United States and China have yet to agree on a formal dialogue dedicated solely to space security issues.[26]

POTENTIAL AREAS FOR FUTURE BILATERAL U.S.-CHINA SPACE COOPERATION

The following section discusses three potential areas for future bilateral cooperation between the United States and China, evaluating them in the context of the principles outlined in the Obama-Hu joint statement. These three examples are not advanced as the only possible areas for cooperation. Rather, these examples, drawn from the US-Soviet experience and suggested by current events, highlight particular challenges and differences between the US-Soviet and the US-China relationships.

HUMAN SPACEFLIGHT

US-China space cooperation on human spaceflight often is considered because of its prominence in both countries and because of its success in bilateral US-Soviet and Russian relations. With both the United States and China actively pursuing human spaceflight programs, many have suggested this as an area ripe for cooperation, perhaps leading toward greater understanding and ultimately a less adversarial relationship. This avenue of potential cooperation has both advantages and disadvantages.

Both countries see their human spaceflight programs as important sources of national prestige, and leaders have been involved personally to varying degrees in associating themselves with their human spaceflight programs. Active involvement by national leaders would be required to overcome bureaucratic inertia or political and military resistance to cooperative US-Chinese ventures in space. While there may not be many space initiatives likely to garner buy-in from the highest political levels; human spaceflight might be one of them.

> *Active involvement by national leaders would be required to overcome resistance to cooperation in space.*

High economic costs and the potential benefits of a cooperative human spaceflight venture might entice US and Chinese leaders into a cooperative venture. Human spaceflight is an enormously expensive undertaking and, while both countries have strong commitment from policymakers to invest large sums of money, it is increasingly the case that, without collaborative funding, some human spaceflight ventures might not be affordable.

There are also strong disadvantages working against human spaceflight as a feasible area of US-China cooperation. The political importance and prestige associated with human spaceflight is accompanied by elements of nationalism and protectionism. The Chinese technical community is justifiably proud about its accomplishments in human spaceflight, without what might be perceived as "help" from other countries, especially the United States. Some US legislators believe that the prestige of human spaceflight cooperation should not be offered until China has made tangible progress on areas such as human rights and freedom of religious practices.

Large, collaborative human spaceflight programs are also likely to engender strong pushback from powerful constituencies . Some would oppose it on ideological grounds, including those who view human spaceflight as wasteful government spending on something that should be done by the private sector, with government funding better spent on tackling social problems such as education or poverty. Political leaders may be unwilling or unable to absorb this pressure, especially if it results in obstacles being created on other high-priority political initiatives.

Differences in national goals might also work against US-China cooperation on human spaceflight. China plans to place its own manned space station into orbit around 2020. It has discussed the possibility of human spaceflight to the Moon, but only as a longer-term potential goal. Meanwhile, the United States is debating the

> *Large, collaborative human spaceflight programs are also likely to engender strong pushback from powerful constituencies.*

future goals of its human spaceflight program. At the moment there is disagreement between the White House and Congress, as well as within Congress and among commentators over whether to return humans to the Moon, visit near Earth asteroids or land humans on Mars. The only apparent area of agreement is that human spaceflight in LEO is not meaningful enough to justify its considerable expense. This mismatch between goals makes it difficult for China and the United States to cooperate on a human spaceflight mission that provides mutual and reciprocal benefits.

Neither the United States nor China would be inclined to pursue a cooperative human spaceflight mission that deviates from overall program goals. Such a mission would be viewed as a detour and as an unnecessary expense, inviting further political, military and bureaucratic resistance. It is also difficult to imagine a cooperative US-China human spaceflight mission in LEO that would provide tangible, mutual benefits, leaving "cooperation for the sake of cooperation" as the primary justification for such a mission.

Chinese participation in the current international human spaceflight program, the ISS, is feasible but unlikely. On the US side, there are considerable hurdles on export control and technology transfer as a result of the International Traffic in Arms Regulations (ITAR) that would need to be cleared. Virtually everything related to space activities was placed under ITAR in the 1990s as a result of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999. Although ITAR regulations are currently undergoing dramatic reform, China is one of the few countries that Congress has stipulated would still be prohibited from exports of space-related hardware or expertise without a license from the US Department of State.[27] Even if these domestic US hurdles were resolved, the legal framework of the ISS project poses additional obstacles. The ISS partnership is based on a multilateral treaty among the United States, Canada, Japan, Russia, and the member states of the European Space Agency.[28] The treaty covers all aspects of ISS operations. Adding China as an official partner to the ISS program or just visits to the ISS by Chinese taikonauts would require the consent of all the ISS partners, each of whom would have their own national political hurdles to work through.

There is also the matter of transportation. Either the Chinese taikonauts would need to reach an agreement with an existing ISS partner to travel on one of their spacecraft, or they would need to use a Chinese spacecraft. The existing Chinese Shenzhou spacecraft would need to have its rendezvous and docking software and procedures modified to comply with ISS docking protocols. Although possible, this would take considerable time and a set of practice and demonstration dockings, similar to those undertaken by SpaceX's Dragon spacecraft as part of its certification process for ISS operations. It would also require considerable organizational learning and adaptation to integrate China as an ISS partner, as was necessary between the US and Russia.

None of these political or technological hurdles is insurmountable, given enough time and political will. There are indications that several of the ISS partners are interested in adding China to the ISS program.[29] Whether these suggestions are fully backed by government policy is unknown. The most critical constraint may be the factor of time. Were this discussion to have taken place earlier in the ISS program, there would have been time to work out the political and technical details. As it stands, the ISS is due to cease operations in 2020 and be deorbited shortly thereafter. Relative to government planning processes, that is a short period of time for making these types of complicated and impactful decisions and reaping their benefits.

Aside from the ISS program, there are other options for Chinese participation in future human spaceflight cooperation. Some have suggested that the United States might help China build its space station, or have US astronauts visit the Chinese space station. Even if this initiative is widely viewed in favorable terms – a questionable assumption – orbital mechanics pose a significant obstacle to this idea. The latitude of a space launch site determines the orbital inclination into which a rocket can launch directly. A rocket could place a payload into an orbital inclination higher than its latitude, but only by using extra fuel and reducing the mass it can place in orbit. It is also possible for a satellite to change its inclination once in orbit, but this requires immense amounts of fuel using chemical propulsion or a very long period of time using electric propulsion.

These practical constraints played a significant role in human spaceflight cooperation between the United States and Russia. The main US space launch site used for human spaceflight, Cape Canaveral in Florida, is located at 28.5 degrees north latitude. The main Russian space launch site used for human spaceflight, the Baikonur Cosmodrome in Kazakhstan, is located at 51.6 degrees north latitude. Typically, objects are launched into space from the lowest latitude possible, especially very heavy objects like modules of a space station, in order to take full advantage of the Earth's rotational velocity. That would suggest locating the ISS at 28.5 degrees north. However, if it were located at 28.5 degrees inclination to better match the latitude of Cape Canaveral, it would be unreachable from Baikonur. Instead, the ISS is orbiting at an inclination of 51.65 because it can reached by rockets launched from both Baikonur and Cape Canaveral as well as French Guiana on the equator, enabling participation in the construction of the ISS by the United States, Russia and Europe.

> *Practical constraints play a significant role in human spaceflight cooperation.*

China currently launches human spaceflight missions from Jiuquan Satellite Launch Center in Inner Mongolia at 40.58 degrees north latitude. Its space station will be assembled via launches from the new Wenchang Satellite Launch Center on Hainan Island at 19.34 degrees north latitude. Unless the future US human spaceflight vehicle has significant excess lift capacity, it will be difficult for the United States to reach the Chinese Space Station from US soil. The only options left are either to launch US astronauts on a Chinese rocket from Wenchang or to develop a new US human spaceflight capability in a location nearer to the equator. Neither option is feasible politically or economically in the foreseeable future.

SOLAR MONITORING AND HELIOPHYSICS

Heliophysics and space weather monitoring could be another area of joint space cooperation. The energy and particles emitted from the Sun interact with the Earth's magnetic shield to create a number of effects on both satellites and ground infrastructure on the Earth. Monitoring of solar activity is critical to developing a better understanding of the Sun, improving the ability to forecast significant space weather events and providing timely warning of disruptive events. While monitoring is done from a wide variety of sensors located in space and on the Earth, some of the most important monitoring is done from satellites located at the Earth-Sun L1 Lagrangian point. This is an

area of space directly between the Earth and the Sun where the gravitational forces of the two balance each other out. A spacecraft placed at the Lagrangian Point can stay in the region without expending a significant amount of fuel and thus be in a prime location to monitor the Sun's activity and provide early warning of solar storms.
Currently, NASA operates a critical spacecraft for this task at the Earth-Sun L1 called the Advanced Composition Explorer (ACE). Another critical spacecraft is operated jointly with the European Space Agency, the Solar and Heliospheric Observatory (SOHO). These two spacecraft are operating far beyond their expected lifespans and are likely to fail in the near future, depriving the world of critical data on the Sun and warnings of potentially harmful events. NASA has recently revived a spacecraft in storage called the Deep Space Climate Observatory (DSCOVR) that will be sent to the Earth-Sun L1 point to provide a few of the most critical solar monitoring functions. DSCOVR will not, however, be able to replace the full suite of instruments on either ACE or SOHO.

China has developed plans for an Earth-Sun L1 monitoring spacecraft of its own called Kuafu as part of a constellation that will include two more satellites in elliptical orbits around the Earth. KuaFu was planned to contain an instrument that, when combined with those on DSCOVR, could replace the most critical capabilities of ACE and SOHO. Heliophysics research and space weather monitoring are essential for understanding the space environment; sharing of the data from these satellites could provide mutual and international benefits. Concerns over technology transfer are not prominent in the area of researching space weather , and collaborative building and launching satellites for the Earth-Sun L1 point is a relatively low-cost endeavor, compared to ambitious collaborative human spaceflight initiatives.

> *Concerns over technology transfer are not prominent in the area of researching space weather.*

The most significant downside to this area for future US-China cooperation is that it may not garner significant, high-level national interest. While a low profile might make it easier to move forward, it might also make it harder to gain the attention of national leaders, whose support will be required to provide the impetus to proceed. Additionally, the modest collaborative venture on space weather could be susceptible to budget cuts and scheduling delays. The decision by the United States to withdraw funding for the joint ExoMars project with the European Space Agency (ESA) serves as a recent example of these pressures.[30] Cost overruns in other parts of NASA's budget and congressional unwillingness to add additional funds forced NASA to drop out of the ExoMars partnership, forcing the ESA to scramble to find new partners.

DIALOGUE AND DATA SHARING ON HIT-TO-KILL TECHNOLOGY

The United States and China place a high priority on developing space capabilities to support national security objectives. These objectives include offensive as well as defensive capabilities. Increased reliance on and activity in space for national security also increases the potential for misunderstandings, misperceptions, friction and unintended escalation. For example, if a critically important national security spacecraft were to be struck by space debris, or subject to a significant space weather event, this could be misinterpreted as an aggressive action.

Of particular concern at present is the demonstrated capacity of China and the United States of hit-to-kill capabilities that could be used either for ballistic missile defense or for anti-satellite (ASAT) attacks. China conducted tests of a ground-based hit-to-kill ASAT system that could reach targets in LEO in 2005, 2006, 2007 and, likely, in 2010.[31] The 2007 test was most notable as it involved the destruction of a Chinese weather satellite and the creation of more than 3,000 pieces of trackable space debris that will present a collision hazard for decades to come.[32] In May 2013, China reportedly tested ASAT technologies that could reach critical US national security satellites in deep space orbits up to and including geostationary Earth orbit (GEO).[33]

Over the same time period, the United States has also conducted hit-to-kill tests of missile defense capabilities, involving both ground-launched and sea-launched interceptors, employing the same general flight profile as China. In February 2008, the United States used its sea-launched SM-3 missile defense interceptor to destroy a failed U.S. reconnaissance satellite that was declared to be a risk to people and structures on the ground if it re-entered the atmosphere intact. The test clearly validated the dual-use nature of direct ascent hit-to-kill capability, either as an ASAT weapon or for missile defense.

These tests provide ample room for worrying assessments of capability and intent, as well as speculation and misinformation. Some analysts and organizations in the United States continue to call for a space-based missile defense capability and even a resurrection of ideas from the 1980s for large constellations of space-based interceptors.[34] Likewise, a number of Chinese military authors have written about the importance of waging warfare and exerting dominance in space.[35] While military planning and testing do not infer political consent to authorize the execution of plans and the use of offensive counter-space capabilities, concerns naturally have grown about whether a military "space race" might be brewing, as well as the role of offensive counter-space capabilities in a potential conflict between the United States and China over Taiwan.

China's development of operational ASAT capabilities could have significantly negative impacts on the US ability to exert military power in space, while an operational US missile defense system and effective prompt global strike capability could undermine Chinese confidence significantly in its limited nuclear deterrent. A dialogue between the United States and China on their respective policies and plans for space warfare-related capabilities, and potentially even a discussion of firebreaks and "red lines" on space activities in the event of a conflict, could improve the bilateral security relationship. More effort on both sides to communicate information about upcoming tests of these systems could also help reduce confusion or misunderstanding that otherwise could lead to heightened tensions or conflict.

Although the benefits to stability from such cooperation are potentially useful, accomplishments will be difficult to achieve. The United States and China view their respective activities in space as critical to national security and will be reluctant to share data. Domestic constituencies in both countries will strongly oppose military space dialogue. It is also unlikely that dialogue will result in binding legal agreements or arms control treaties – a Chinese diplomatic objective – as was the case for dialogue between Washington and Moscow. There are significant verification challenges for a legally binding agreement covering ASAT capabilities, unlike agreements on strategic nuclear delivery vehicles between Washington and Moscow. Dual use hit-to-kill capabilities are much more difficult to limit. The limitations of monitoring capabilities and the presence of dual-use capabilities would mean that parties to an agreement would not place trust in its limitations. While legally binding agreements do not appear feasible, other reasons for dialogue might well be mutually beneficial.

CONCLUSION

Although there are some similarities between the current US-China relationship in space and the US-Soviet relationship, the differences far outweigh them. What worked during the Cold War might not work between Washington and Beijing. The incongruity between current space capabilities and long-term goals between the United States and China presents a stark contrast to the parallelism of US and Soviet space programs. These disparities might be resolved over time or set aside by national leaders in search of cooperative ventures in space. Otherwise, the range of options for possible US-Chinese cooperation in space will be severely restricted.

Two general paths forward for US-China space cooperation lie ahead, if national leaders are willing to proceed. The first is a top-down approach, built around high-profile initiatives such as human spaceflight. The involvement of national leaders will be necessary to overcome bureaucratic inertia and resistance to such cooperation. The second is a bottom-up approach, involving low-profile areas of cooperation unlikely to generate significant opposition and controversy, such as collaborative scientific research and space science missions. This approach is likely to cost less in terms of money and political capital but will require institutional champions on both sides.

Which approach is more likely to succeed depends on a deeper understanding of the organizations and interests that might seek to advance or oppose these initiatives, which is beyond the scope of this essay. If an area of scientific study or a space applications concept with sufficient institutional champions can be identified, a bottom-up approach is likely to be more successful. If strong institutional champions are absent on one side or both, and then high-level national engagement through a top-down approach will be required for collaborative spaceflight initiatives. In either case, tangible benefits from cooperation are likely to carry much more weight than mere optimism in pushing a cooperative program forward.

> *What worked during the Cold War might not work between Washington and Beijing.*

The choice of approach also depends on the main goal of US-China cooperation in space activities and the time period for desired results. If the primary goal is to reduce misunderstandings and misperceptions and foster strategic stability in the near-term, then a top-down approach involving security issues is warranted. Alternatively, if the primary goal is to foster institutional cooperation on matters of mutual interest and develop long-term understanding and relationships, a bottom-up approach led by scientists is likely preferable.

Settling on a single initiative for US-China cooperation limits possibilities, and is therefore not the best option. A better approach would be to develop a clear strategy for US-China engagement that mixes top-down and bottom-up joint initiatives. Bottom-up initiatives might include data sharing, policy dialogues on national security topics and joint space science projects. Given the difficulties associated with increasing cooperation on space-related issues, interventions and policy impulses from national leaders in Washington and Beijing would likely be required, even for modest initiatives. The more ambitious the initiative, the greater the effort that will be required by national leaders. Whether the United States and China have the political will to undertake such an effort to develop and undertake a broad strategy remains to be seen.

1. See the text the joint statement published by the White House on Jan. 19, 2011, http://www.whitehouse.gov/the-press-office/2011/01/19/us-china-joint-statement.
2. Rep. Frank Wolf, R-Va., "Wolf: U.S. should not cooperate with People's Liberation Army to help develop China's space program," statement to the House Foreign Affairs Subcommittee on Oversight and Investigations, Nov. 2, 2011, http://wolf.house.gov/index.cfm?sectionid=34&itemid=1813.
3. Jeffrey Logan, "China's Space Program: Options for U.S.-China Cooperation", Congressional Research Service, Sept. 29, 2008, http://assets.opencrs.com/rpts/RS22777_20080929.pdf .
4. See the text the joint statement published by the White House on Jan. 19, 2011, http://www.whitehouse.gov/the-press-office/2011/01/19/us-china-joint-statement.
5. The constitutionality of the budget injunction against any NASA spending on bilateral cooperation with China is an unsettled question. Congress insists that it is a spending issue, which the Constitution places under its jurisdiction. The White House asserts that it is a foreign policy issue, which the Constitution places under the sole jurisdiction of the executive branch. For the time being, the White House has decided not to press the matter with Congress in the hopes of getting congressional support on other matters, including its plans for human spaceflight.
6. For a thorough examination of these three lenses, see Graham T. Allison and Philip Zelikow, *Essence of decision: Explaining the Cuban Missile Crisis*, 2nd Ed. (New York: Pearson, 1999).
7. Paul Rincon, "X-37B US Military Spaceplane Returns to Earth", BBC News, Dec. 3, 2010, http://www.bbc.co.uk/news/science-environment-11911335.
8. For example, see Austin Jameson, *X-37 space vehicle: Starting a new age in space control?* (Maxwell Air Force Base, Ala.: Air University, 2001), http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA407255.
9. Brian Weeden, "X-38B orbital test vehicle fact sheet," Secure World Foundation, Nov. 23, 2010, http://swfound.org/media/1791/x-37b_otv_factsheet.pdf.
10. Brian Weeden, *Going Blind: Why America Is on the Verge of Losing Its Situational Awareness in Space and What Can Be Done about It*, (Broomfield, Colo.: Secure World Foundation, 2010) 36, http://swfound.org/media/90775/going_blind_final.pdf.
11. Kai-Uwe Schrogl, Charlotte Mathieu, & Nicolas Peter, *Yearbook in Space Policy 2006/2007: New Impetus for Europe* (Vienna: Springer: Vienna, 2008), 216.
12. Peter de Selding, "China Wants to Take Out the Trash," NBCNews.com, Sept. 4, 2007, http://www.nbcnews.com/id/20587864/ns/technology_and_science-space/t/china-wants-take-out-space-trash/#.UgjaAZLbOSp.
13. Gregory Kulacki and Jeffrey Lewis, "Understanding China's ASAT test," Union of Concerned Scientists, Oct. 31, 2008, http://www.ucsusa.org/nuclear_weapons_and_global_security/international_information/us_china_relations/understanding-chinas-asat.html.
14. Tiffany Chow, "UNCOPUOS Long-term Sustainability of Space Activities Working Group Fact Sheet," Secure World Foundation, June 2013, http://swfound.org/media/109514/SWF_UNCOPUOS_LTSSA_Fact_Sheet_June_2013.pdf.
15. Tiffany Chow, "Group of Governmental Experts on Transparency and Confidence Building Measures in Space Activities Fact Sheet," Secure World Foundation, June 2013, http://swfound.org/media/109311/SWF%20-%20GGE%20Fact%20Sheet%20-%20June%202013.pdf.
16. Frank Rose, Remarks for the International Space Reception Panel, July 24, 2013, http://www.state.gov/t/avc/rls/2013/212514.htm.
17. Tiffany Chow, "Draft International Code of Conduct for Outer Space Activities Fact Sheet," Secure World Foundation, May 2013, http://swfound.org/media/83247/icoc_factsheet_may2013.pdf .
18. See charts of historical launches compiled by Jonathan McDowell, http://www.planet4589.org/space/log/stats1.html.
19. See chart compiled by Brian Weeden on yearly US space launches by category, https://docs.google.com/spreadsheet/ccc?key=0Av6GZ3zk7v4OdE5hWGVVdkl3TjdiWmJjb2c5dVpsM3c#gid=15.

20. See charts of historical launches compiled by Jonathan McDowell, http://www.planet4589.org/space/log/stats1.html.
21. Brian Weeden, "Timeline of Human Spaceflight Programs," Secure World Foundation, Sept. 7, 2012, http://swfound.org/media/90819/SWF%20-%20Human%20Spaceflight%20Programs%20Fact%20Sheet%20Sept%202012.pdf.
22. Priyadarshi Siddhanta, "Plan Panel Okays ISRO Manned Space Flight," The Indian Express, Feb. 23, 2009, http://www.indianexpress.com/news/plan-panel-okays-isro-manned-space-flight/426945/.
23. The ISS program began as a unilateral US effort called Space Station Freedom in the 1980s. It later became a joint project that combined elements of Freedom with Soviet plans for a second Mir and Japanese and European plans for scientific modules.
24. "China's Permanent Magnet Sent into Space," Permanent Magnet, March 29, 2013, http://www.chinamagnet.us/chinas-permanent-magnet-sent-into-space.htm.
25. Stephen Clark, "Nearly 400 Satellite Crash Reports Sent to Russia, China," Spaceflight Now, June 15, 2011, http://www.spaceflightnow.com/news/n1106/15debris/.
26. Andrea Shalal-Esa, "Space Plays a Growing Role in U.S.-China Security Talks: Official," Reuters, April 11, 2013, http://www.reuters.com/article/2013/04/12/us-usa-china-space-idUSBRE93B01W20130412.
27. See H.R. 4310, National Defense Authorization Act for Fiscal Year 2013, Section 1261 para C (2)a, http://www.govtrack.us/congress/bills/112/hr4310/text.
28. See "International Space Station Legal Framework," European Space Agency, May 8 2013, http://www.esa.int/Our_Activities/Human_Spaceflight/International_Space_Station/International_Space_Station_legal_framework.
29. George Abbey and Leroy Chiao, "Time for the U.S. to Partner with China in Space?" Discovery.com, Dec. 13, 2012, http://news.discovery.com/space/private-spaceflight/opinion-nasa-partner-china-politics-spaceflight-gap-121127.htm.
30. Ken Kremer, "Experts React to Obama Slash to NASA's Mars and Planetary Science Exploration," Universe Today, Feb. 17, 2012, http://www.universetoday.com/93512/experts-react-to-obama-slash-to-nasas-mars-and-planetary-science-exploration/ .
31. China has characterized the 2010 test as that of a missile defense interception. See Dean Cheng, "China's Space Program: A Growing Factor for U.S. Security Planning", Heritage Foundation, Aug. 6, 2011, http://www.heritage.org/research/reports/2011/08/chinas-space-program-a-growing-factor-in-us-security-planning
32. Brian Weeden, "2007 Chinese Antisatellite Test Fact Sheet," Secure World Foundation, Nov. 23, 2010, http://swfound.org/media/9550/2007_chinese_asat_test_factsheet.pdf.
33. Andrea Shalal-Esa, "U.S. Sees China Launch as Test of Antisatellite Muscle: Source," Reuters, May 15, 2013, http://www.reuters.com/article/2013/05/15/us-china-launch-idUSBRE94E07D20130515.
34. For example, see the 2009 report from the Independent Working Group on "Missile Defense, the Space Relationship, and the Twenty-First Century," Institute for Foreign Policy Analysis, http://www.ifpa.org/pdf/IWG2009.pdf.
35. Paul Oh, "Assessing Chinese Intentions for the Military Use of the Space Domain," Joint Forces Quarterly, Issue 64 (1st Quarter 2012), http://www.ndu.edu/press/lib/pdf/jfq-64/JFQ-64_91-98_Oh.pdf.

Annex: A Comparison of Nuclear and Anti-satellite Testing, 1945-2013

By Michael Krepon and Sonya Schoenberger

To date, the United States, Soviet Union and China have conducted 1,790 tests of nuclear devices. In contrast, these three major powers appear to have carried out 61 anti-satellite (ASAT) tests. The great disparity in these numbers suggests that major powers have previously deemed ASAT tests to be strategically unwise, unimportant or unnecessary.

Now these calculations may be subject to change – at least by Beijing and Washington. While nuclear testing by major powers continues to recede in the rear-view mirror – Moscow last carried out a nuclear test in 1990, the United States in 1992 and China in 1996 – ASAT testing, or testing ASAT capabilities through other means, is being revived by the People's Liberation Army (PLA) and the Pentagon. Moscow has had difficulty reconstituting its strategic and military space programs. Its last dedicated ASAT test was in 1982, over 30 years ago. Russian officials may well be interested in resurrecting these capabilities, but have not, as yet, tested them.

The situation is quite different in China and the United States. Beijing has a very active program to advance its ASAT capabilities. Over the past decade – a period that coincides with the withdrawal by President George W. Bush's administration from the Anti-ballistic Missile Treaty – the PLA appears to have attempted six anti-satellite tests.[1] A January 2007 test successfully demonstrated "hit-to-kill" technology after failed attempts in 2005 and 2006.[2] Subsequent to the successful intercept in 2007, the PLA has conducted two declared missile defense tests in 2010 and 2013,[3] and one high-altitude rocket launch in May 2013 [4] suspected to be related to the advancement of Chinese ASAT capabilities.[5]

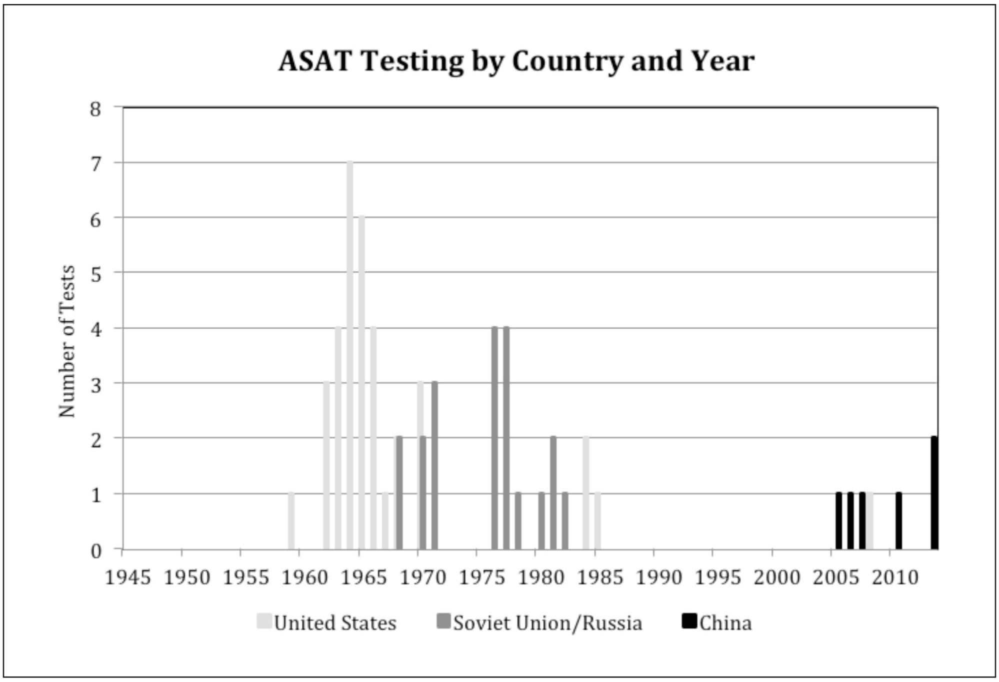
Over the same period, the United States demonstrated agile, sea-based ASAT capability by shooting down a nonfunctioning satellite in February 2008, ostensibly for reasons of public safety. [6] In addition, the United States has carried out 76 attempted missile defense tests since 2001.[7] Most of these tests have been of theater missile defense capabilities. There is a significant technological crossover between missile defense and ASAT technologies. The United States and China have other options to interfere with or damage satellites. Both have tested close proximity maneuvers in space, and both could employ ground-based lasers and jammers to interfere with or harm satellites.

This annex compares the numbers of nuclear and ASAT tests carried out by the United States, the Soviet Union and China. The count for U.S. and Chinese ASAT tests over the past decade is debatable for the reasons mentioned above. The U.S. count may be low, given the Pentagon's learning curve with respect to theater missile defense tests. The Chinese count may be high, if Chinese claims for ballistic missile defense testing are to be believed. Regardless of the number of tests of a predominantly or demonstrably ASAT character over the past decade, these charts clarify that, while the number of ASAT tests is but a small percentage of the number of earlier nuclear tests, the presumed value of ASAT testing, or ASAT testing through other means, is growing. As was the case with ASAT testing by the United States and the Soviet Union during the Cold War, U.S. and Chinese leaders have important decisions to make about whether to ratchet up their ASAT-related testing programs or to reach tacit, informal or executive agreements to dampen this competition.

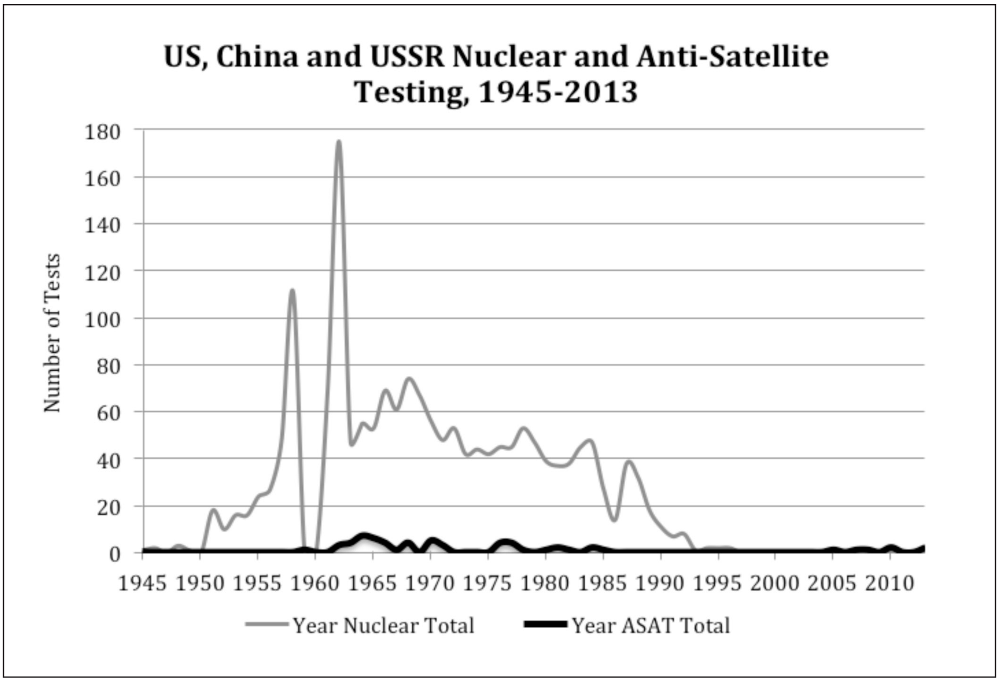
ASAT test programs suffer initial failures. According to data compiled by Paul Stares, of the 53 U.S. and Soviet ASAT tests through 1984, only 58 percent might be considered to be successful. The U.S. success rate was 70 percent; the Soviet success rate was 45 percent.[8] Press reports suggest that the PLA also experienced two failures before the successful ASAT intercept in 2007 that produced the largest human-made debris cloud of the Space Age.[9] Failure rates will become more difficult to assess in the absence of intended hit-to-kill tests and the prevalence of tests designed to advance ASAT capabilities through indirect means. Absent diplomatic efforts to deal with emerging ASAT capabilities, more demonstrations of ASAT capabilities by indirect means are likely in the coming years.

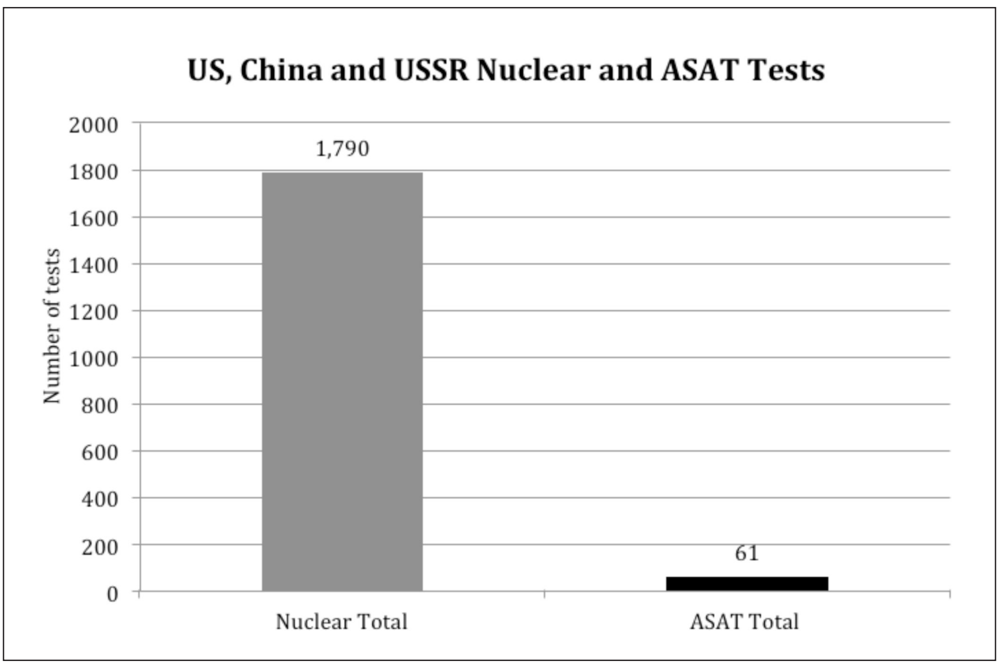
It is not too late to dampen an emerging competition in ASAT capabilities. One especially useful approach would be to establish a norm against further ASAT tests that produce long-lasting debris fields. This norm could be embedded in an International Code of Conduct for responsible spacefaring nations.

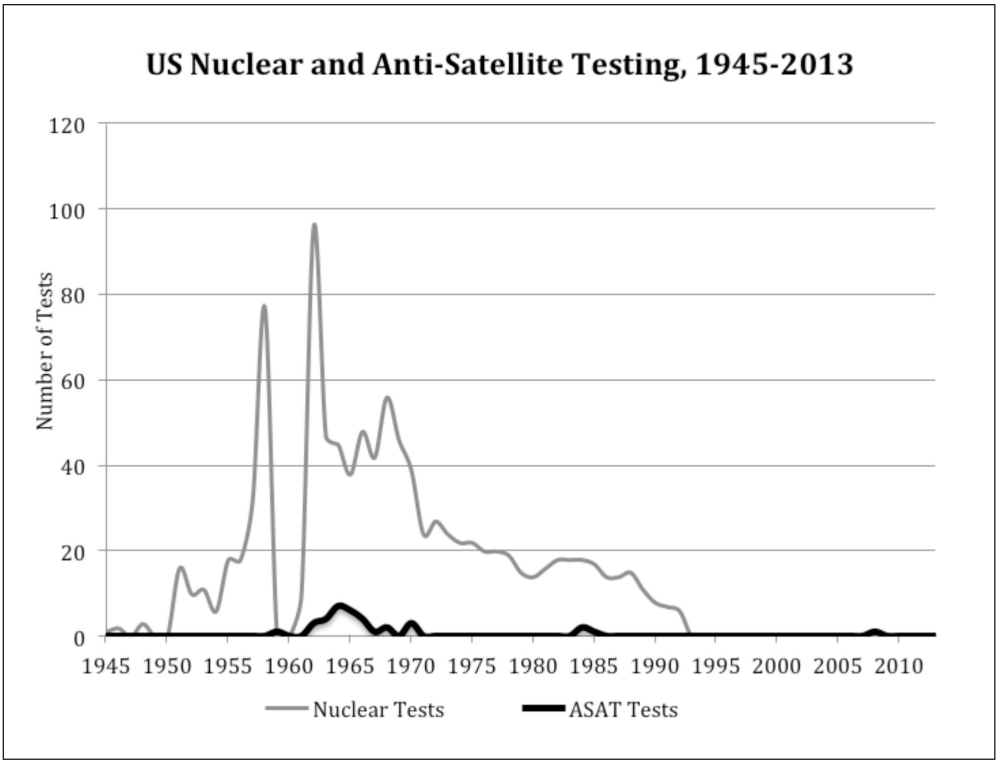
This annex relies upon data from several sources. For nuclear testing, this report relies upon the National Resource Defense Council's databases.[10] The data in the accompanying graphs include tests carried out as "peaceful nuclear explosions" (PNEs), because it is difficult to distinguish between tests of PNEs and tests that provide military utility. For Cold War ASAT tests though 1984, this report relies on data compiled by Paul Stares.[11] For tests of a predominantly or demonstrably ASAT character over the past decade, this report uses data from the Secure World Foundation's August 2013 Fact Sheet on "Anti-Satellite Tests in Space – The Case of China,"[12] government press releases and media accounts.

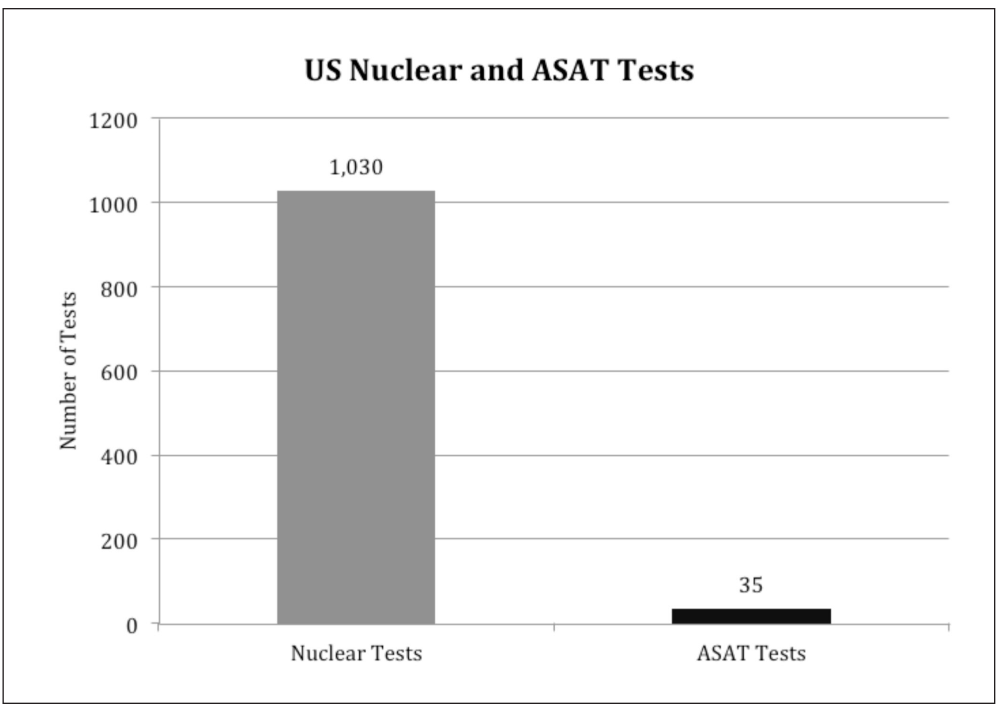


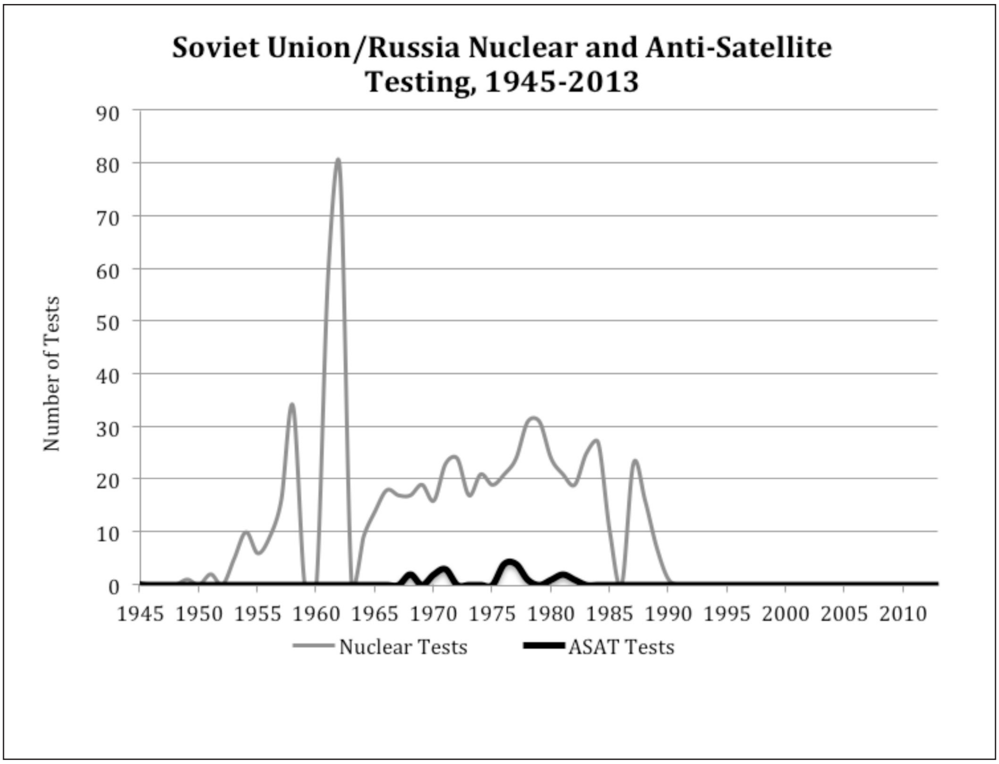
1. Brian Weeden, "Anti-satellite Tests in Space – The Case of China," Secure World Foundation, August, 2013.
2. Ibid.
3. Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2013*, (Washington, D.C.: US Department of Defense Publications, 2013), 36, http://www.defense.gov/pubs/2013_china_report_final.pdf.
4. Shalal-Esa, Andrea, "US Sees China Launch as Test of Anti-satellite Muscle: Source," Reuters, May 15, 2013, http://www.reuters.com/article/2013/05/15/us-china-launch-idUSBRE94E07D20130515; Mike Wall, "China Launches High-Altitude Rocket on Apparent Science Mission: Reports," SPACE.com, May 15, 2013, http://www.space.com/21161-china-suborbital-rocket-launch.html; Brian Weeden, "Time for Obama to Go Public on China's ASAT Program," *Defense News*, June 2, 2013, http://www.defensenews.com/article/20130602/DEFREG/306020009/Time-Obama-Go-Public-China-s-ASAT-Program.
5. Weeden,"Anti-satellite Tests in Space – The Case of China."
6. US Department of Defense, "DoD Succeeds in Intercepting Non-Functioning Satellite," News Release No. 0139-08, Feb. 20, 2008, http://www.defense.gov/releases/release.aspx?releaseid=11704.
7. Missile Defense Agency, "Ballistic Missile Defense Intercept Flight Test Record," Fact Sheet, July 8, 2013, http://www.mda.mil/global/documents/pdf/testrecord.pdf.
8. Paul Stares, *The Militarization of Space: US Policy, 1945-1984* (Ithaca, N.Y.: Cornell University Press, 1985), Appendix II, 261-262.
9. Office of the Secretary of Defense, "Annual Report to Congress," 33, http://www.defense.gov/pubs/2013_china_report_final.pdf.
10. Natural Resources Defense Council, "Table of Known Nuclear Tests Worldwide: 1945-1969, 1970-1996," Archive of Nuclear Data, http://www.nrdc.org/nuclear/nudb/datab15.asp
11. Stares, *The Militarization of Space*, 261-262.
12. Weeden"Anti-satellite Tests in Space The Case of China."


US, China and USSR Nuclear and Anti-Satellite Testing, 1945-2013
Number of Tests
180
160
140
120
100
80
60
40
20
0
1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010
Year Nuclear Total
Year ASAT Total

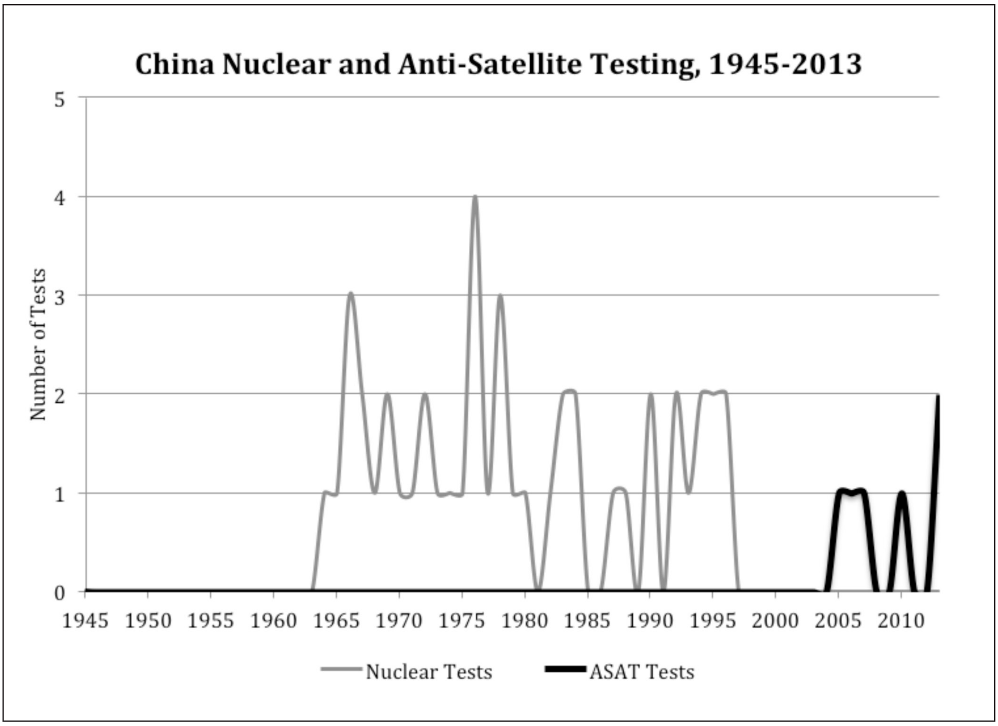

US, China and USSR Nuclear and ASAT Tests
Number of tests
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1,790
61
Nuclear Total
ASAT Total

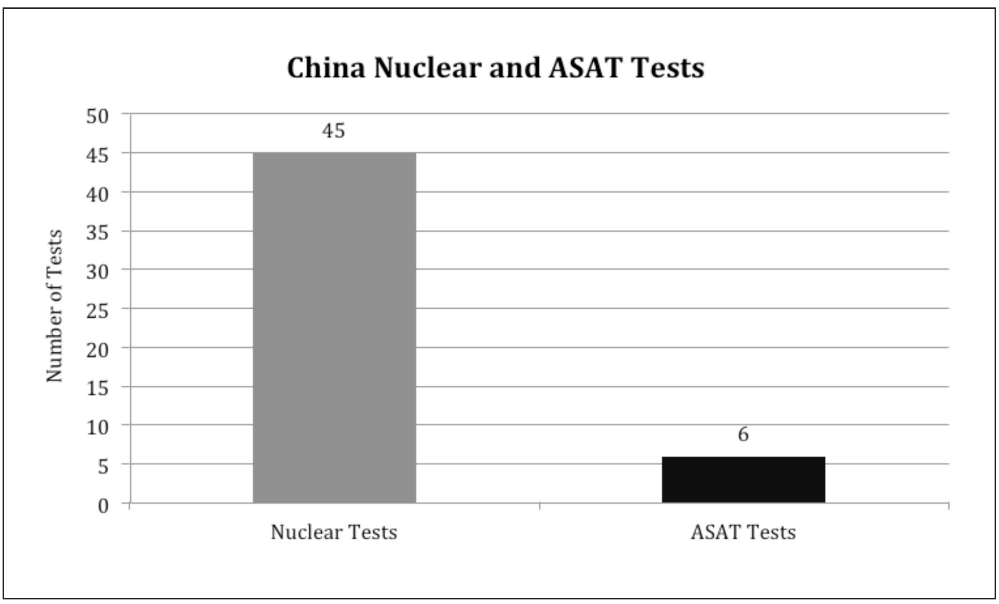

US Nuclear and Anti-Satellite Testing, 1945-2013
Number of Tests
120
100
80
60
40
20
0
1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010
Nuclear Tests
ASAT Tests


US Nuclear and ASAT Tests
Number of Tests
1200
1000
800
600
400
200
0
1,030
35
Nuclear Tests
ASAT Tests


Soviet Union/Russia Nuclear and Anti-Satellite Testing, 1945-2013
Number of Tests
90
80
70
60
50
40
30
20
10
0
1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010
Nuclear Tests
ASAT Tests


Soviet Union/Russia Nuclear and ASAT Tests
Number of Tests
800
700
600
500
400
300
200
100
0
715
20
Nuclear Tests
ASAT Tests


China Nuclear and Anti-Satellite Testing, 1945-2013
Number of Tests
5
4
3
2
1
0
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Nuclear Tests
ASAT Tests


China Nuclear and ASAT Tests
Number of Tests
50
45
40
35
30
25
20
15
10
5
0
45
6
Nuclear Tests
ASAT Tests

Author Biographies

Ambassador Lincoln P. Bloomfield, Jr. is Chairman of the Stimson Center. He was the U.S. Special Envoy for MANPADS Threat Reduction (reducing the availability to terrorists of shoulder-fired missiles) from 2008-09, Assistant Secretary of State for Political Military Affairs and Special Representative of the President and Secretary of State for Humanitarian Mine Action from 2001-2005, Deputy Assistant Secretary of State for Near Eastern Affairs from 1992-93, Deputy Assistant to the Vice President for National Security Affairs from1991-02, and Principal Deputy Assistant Secretary of Defense for International Security Affairs from1988-89 among other policy positions in DoD beginning in 1981. He has authored a number of articles on space security issues drawing insights from his participation in Pentagon-sponsored wargames. Mr. Bloomfield is a graduate of Harvard College and the Fletcher School of Law and Diplomacy.

Michael Krepon is the co-founder of the Stimson Center. His areas of expertise are space security and nuclear arms control and proliferation, with a regional specialization in South Asia. Before co-founding the Stimson Center in 1989, he worked at the Carnegie Endowment, the Arms Control and Disarmament Agency at the State Department, and on Capitol Hill. His books include *Better Safe than Sorry, The Ironies of Living with the Bomb; Space Assurance or Space Dominance: The Case Against Weaponizing Space; Open Skies, Arms Control and Cooperative Security; Commercial Observation Satellites and International Security; Cooperative Threat Reduction, Missile Defense, and the Nuclear Future; and Rummaging in Shoeboxes for Stories about the Bomb, the Nuclear Age and Arms Control.*

Ellen Laipson is president and chief executive officer of Stimson. Laipson joined Stimson in 2002, after 25 years of government service. Key positions included vice chair of the National Intelligence Council (NIC) (1997-2002) and special assistant to the U.S. permanent representative to the United Nations (1995-97). Her earlier government career focused on analysis and policymaking on Middle East and South Asian issues. She was director for Near East and South Asian Affairs for the National Security Council (1993-95), national intelligence officer for Near and South Asia (1990-93), a member of the State Department's policy planning staff (1986-87), and a specialist in Middle East affairs for the Congressional Research Service. She was a member of President Obama's Intelligence Advisory Board from 2009-2013, and since 2011, has served on the Secretary of State's Foreign Affairs Policy Board. Laipson has an M.A. from the School of Advanced International Studies, Johns Hopkins University and a B.A. from Cornell University.

James A. Lewis is a senior fellow and Program Director at the Center for Strategic and International Studies, where he writes on technology, security and the international economy. Before joining CSIS, he served at the Departments of State and Commerce as a Foreign Service Officer and as a member of the Senior Executive Service. Lewis has authored more than eighty publications since coming to CSIS.

Bruce W. MacDonald teaches at the United States Institute of Peace on strategic posture and space/cyber security issues, leads a study on China and Crisis Stability in Space, and is adjunct professor at the Johns Hopkins School of Advanced International Studies. He was Senior Director to the Perry-Schlesinger Strategic Posture Review Commission at USIP and project leader for the Council on Foreign Relations' study of China and Space Weapons. Mr. MacDonald was Assistant Director for National Security at the White House Office of Science and Technology Policy and served on the NSC staff. Earlier he was a professional staff member of the House Armed Services Committee for space and missile defense and was a nuclear weapons/space specialist at the State Dept., chairing the Interagency START Working Group and serving on the U.S. START delegation in Geneva. Mr. MacDonald graduated with honors in aerospace engineering from Princeton, where he earned two masters degrees in aerospace engineering/public policy. He is a Council on Foreign Relations member.

Karl P. Mueller is a senior political scientist at the RAND Corporation, where he specializes in research related to military and national security strategy, particularly coercion and deterrence. He is also the associate director of the RAND Arroyo Center's Strategy and Resources Program and a faculty member in the Pardee RAND Graduate School, and teaches strategy and security studies at Johns Hopkins and Georgetown Universities.. Before joining RAND in 2001, Dr. Mueller was a professor of comparative military studies at the USAF's School of Advanced Air and Space Studies (SAASS). He has written and lectured on a wide variety of national security subjects, including airpower theory, grand strategy, economic sanctions, nuclear proliferation, counterterrorism policy, and space weapons; his most recent research has focused on escalation management, no-fly zones, and the use of airpower in the Libyan civil war.

Michael Nacht is the Thomas and Alison Schneider Professor of Public Policy in the Goldman School of Public Policy at the University of California, Berkeley. He served as Aaron Wildavsky Dean of the School from 1998-2008. He was Assistant Secretary of Defense for Global Strategic Affairs from 2009-2010, after unanimous U.S. Senate confirmation, with responsibilities for nuclear weapons, missile defense, space policy, cyber policy, and counter-proliferation. He received the Distinguished Public Service Award, the Department's highest civilian honor. He was previously Assistant Director for Strategic and Eurasian Affairs in the U.S. Arms Control and Disarmament Agency from 1994-1997 where he participated in five Clinton presidential summits, four with Russian President Yeltsin and one with Chinese President Zhang Zemin.

Sonya Schoenberger is a student at Washington University in St. Louis, studying history, geophysics, and economics. She interned with the Space Security program in June-August 2013.

Julia Thompson is a Research Associate with the Space Security program. Before joining Stimson, she worked as a research intern at National Defense University's Institute for National Strategic Studies. She is a graduate of Georgetown University and King's College London.

Brian Weeden is the Technical Advisor for Secure World Foundation, where he conducts research on space debris, global space situational awareness, space traffic management, protection of space assets, and space governance. He also organizes national and international workshops to increase awareness of and facilitate dialogue on space security and sustainability topics. Prior to joining the Foundation, Mr. Weeden served 9 years on active duty as an officer in the United States Air Force working in space and intercontinental ballistic missile (ICBM) operations. As part of U.S. Strategic Command's Joint Space Operations Center (JSpOC), Captain Weeden directed the orbital analyst training program and developed tactics, techniques and procedures for improving space situational awareness. Respected and recognized as an international expert, Mr. Weeden's research and analysis have been featured in *The New York Times, National Public Radio, USA Today, The BBC, Fox News, China Radio International, The Economist*, The World Economic Forum's Annual Meeting in Davos, academic journals, presentations to the United Nations, and testimony before the U.S. Congress. He is also Vice-Chair of the World Economic Forum's Global Agenda Council on Space Security.

$0.00
ISBN 978-1-939240-05-7
90000>
9 781939 240057

1111 19th Street, NW, 12th Floor, Washington, DC 20036
P 202.223.5956 F 202.238.9604

www.stimson.org